POWER PLANT ENGINEERING

Established Over 32 Years

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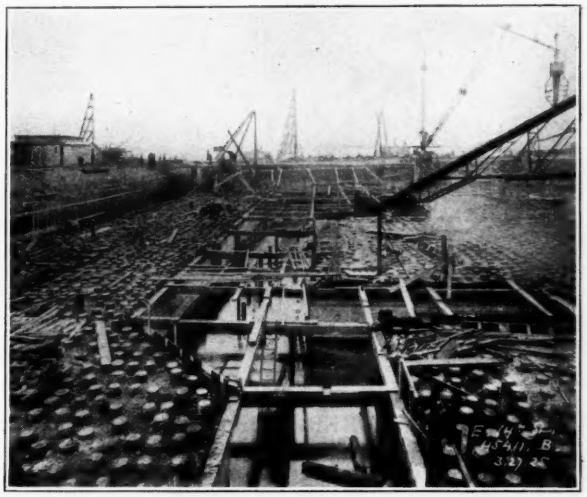


Hydro-therapeutics for Plant Fever

BR-R-R-R-R ! — br-r-r-r-r ! — br-r-r-r-r !

Dr. Howard half consciously reached over to the desk beside his bed for the telephone and answered:

"Howard speaking."

"Say, doctor," came an excited voice from the other end of the line, "I don't know what to do with the old girl down here—temperature's up to a hundred-and-five and I have done everything I know to keep up circulation but she seems to be dying on me."

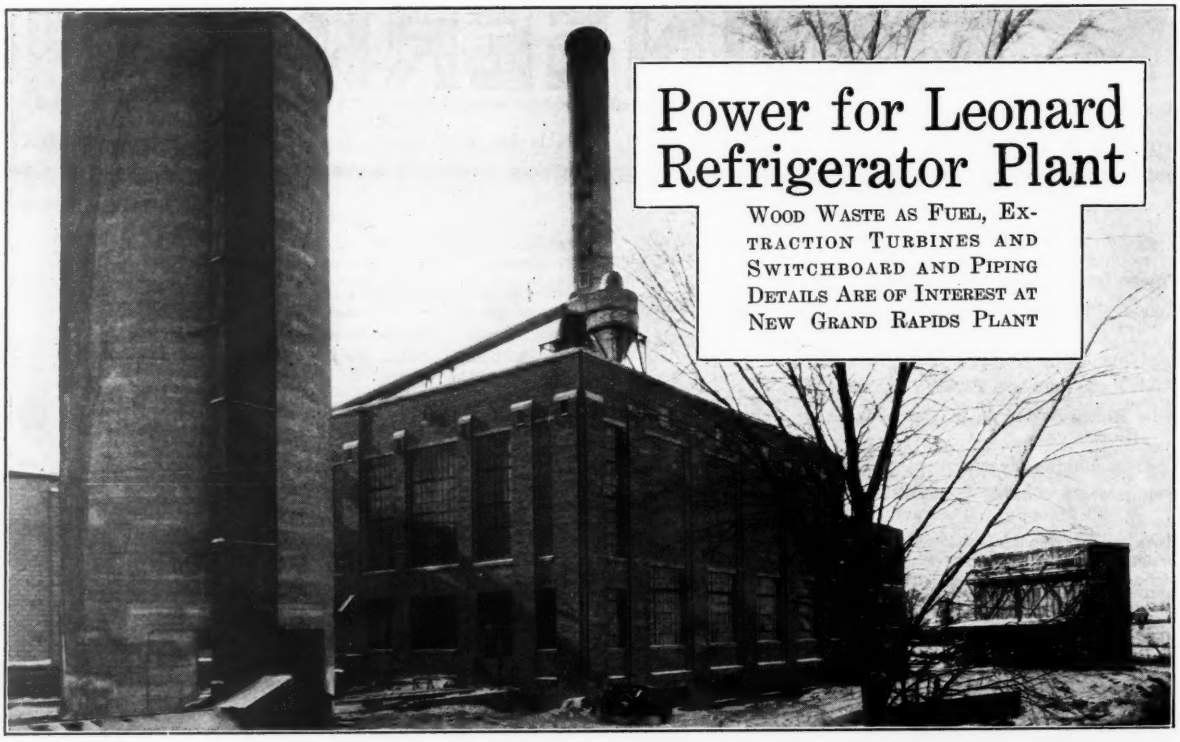
"Looks like it—high fever and low pulse. Give her a sweat and pack her head in ice. I'll be over in ten minutes."

"Ah, quit your kidding! What can I do to keep the unit on the line till you get over."

"Unit! What are you talking about? Isn't this Dr. Young, intern at the hospital, talking about that pneumonia case?"

"I should say not; this is Bill, the operator at the public service plant. I thought I was talking to Howard, Doctor of Mechanical Engineering, superintendent of our plant; I can't get water to the condenser. Excuse me—wrong number."

In the beginning, water—that seems to be a determinant of steam power plant design and in the picture shown above we observe how the circulating system is built into the foundation of East River Station. Other systems for administering hydro-therapeutics to condensers suffering with fever and ague as well as indigestion will be found described on page 448 of this issue.



Power for Leonard Refrigerator Plant

Wood Waste as Fuel, Extraction Turbines and Switchboard and Piping Details Are of Interest at New Grand Rapids Plant

LAST OCTOBER at Grand Rapids, Mich., the Leonard Division of the Electric Refrigeration Corp. placed in operation a new power plant to serve the great factory in which Leonard Refrigerators are made. Changes and additions in the manufacturing departments of this factory have been necessary and the old plant could not continue to meet the new conditions economically. As a large amount of sawdust and other wood waste is available as a by-product of the factory and as considerable amounts of steam are needed for heating and for the large dry kilns, analysis showed that installation of power generating equipment was justified.

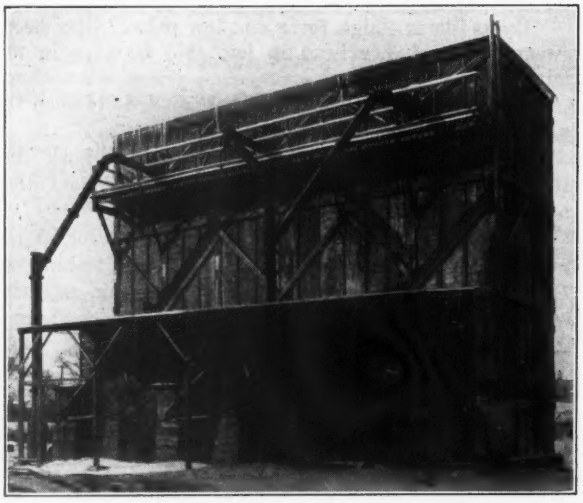


FIG. 1. COOLING TOWER CONSERVES WATER FOR CONDENSERS OF TWO EXTRACTION TURBINES

Accordingly, the new plant was designed to have a total generating capacity of 2700 kw. and to include two extraction type turbo-generators from which steam at atmospheric pressure could be bled to the dry kilns, the vacuum heating system and for other industrial processes. A new porcelain plant, where porcelain enamel is applied to the refrigerator parts, is served with power by the public utility company. Provision has been made in the power house design, however, for installation of additional generating capacity in case the company decides to make power for the porcelain plant instead of buying it. This purchased power load is about 700 kw.

To supply steam, three new vertical water-tube boilers were installed and a fourth unit of the same size was taken from the old plant and put in place in the new boiler room, but has not yet been connected up. Sawdust and hogged fuel are burned under these boilers, supplemented by coal when necessary.

Some sections of the mill and some of the process machinery are wired for direct current; in addition, an extensive tram-rail system is used for handling material in the porcelain plant and for transporting finished parts from this plant to the assembly departments. To supply this d.c. service, a 350-kw. motor generator set was installed; a synchronous motor drives this unit and affords power factor correction.

Extraction Turbines Supply Steam to Factory

Of particular interest in this plant is the well arranged turbine room shown in Fig. 3. Here we find two main units of the extraction type, each of 1250-kw. capacity. These take steam at 170 lb. gage and 70—100 deg. superheat, depending on the load. Part of the steam is extracted at approximately atmospheric pres-

sure for dry kilns and vacuum heating system, the remainder passing to the condensers. Each main unit condenser has a surface of 3000 sq. ft.

To supply cooling water for these condensers, a cooling tower is installed, as shown in Fig. 1 and in the headpiece. Makeup water for the cooling tower comes originally from a deep well just behind the power house. The tower is of wood construction throughout, air being circulated through it by three 12-ft. forced draft fans, each driven through a texrope drive from a 20-hp. induction motor. Two pumps force the water to be cooled to the top of the tower, which is designed to cool 3200 g.p.m. from 105 deg. to 85 deg. when the atmospheric temperature is 80 deg. with 65 per cent relative humidity. Motor-driven circulating pumps supply the water to the condensers.

Mounted on the turbine room floor, the steam jet air pumps of these condensers are readily accessible at all times to the turbine operator for inspection or adjustment.

To supply power at night or whenever extremely light load conditions prevail, a 200-kw. non-condensing turbo-generator was installed, shown in the foreground of Fig. 3. Another generating set, consisting of a single-cylinder vertical steam engine direct-connected to a generator, was removed from the old plant and set up here for emergency standby service.

Either of two 35-kw. exciters, one motor and one turbine-driven, supplies excitation through an exciter bus to the generating units.

Switchboards and Electrical Circuits

Switchboards and wiring in the Leonard plant, besides presenting an extremely attractive appearance,

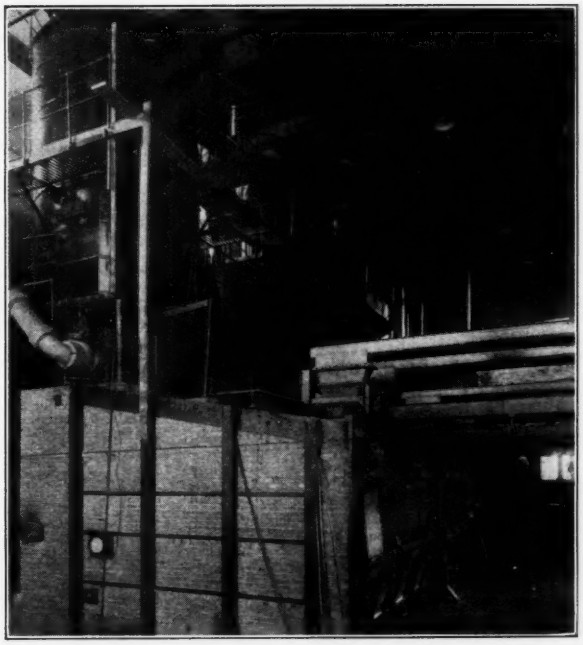


FIG. 2. SCREW CONVEYORS FEED WOOD WASTE TO FURNACES WITH HOLLOW SIDE WALLS UNDER 508-HP. VERTICAL WATER-TUBE BOILERS

possess several unusual features. Two switchboards are installed. The main board, shown in Fig. 3, carries meters and controls for solenoid-operated air break circuit breakers on the generator circuits and distribution panels for the outgoing factory circuits. A second board, at one side of the main board, carries small en-

FIG. 3. NEW TURBINE ROOM CONTAINS TWO 1250-KW. EXTRACTION TURBO-GENERATORS, ONE 200-KW. NON-CONDENSING UNIT AND EXCITERS. CONDENSER AIR PUMPS AT RIGHT, 350-KW. M—G. SET AT LEFT

closed air circuit breakers for control of the auxiliaries such as circulating pumps, exciters and the like. This arrangement, employing a separate board for auxiliaries, is seldom found in an industrial plant.

Double bus system is used on the auxiliary board, with a throwover device that automatically transfers certain connections on this board from the main bus directly to the generator leads, in case any trouble develops in the bus that causes the main circuit breaker to trip. All circuits from the distribution panels and auxiliary board run in conduit down to a junction box about 30 ft. long on the under side of the turbine room floor. From this box the circuits then run in conduit out to the mill. Power is generated at 480 v., 3 phase, 60 cycles, and distributed direct without transformation. An interesting item is the use of a small air conditioner to purify the generator cooling air.

On the turbine room floor, a new 825-c.f.m. steam-driven air compressor was installed to supply air at 100 lb. gage, while below in the turbine room basement another compressor of 400 c.f.m. capacity, brought from the old plant, was put in. These compressors supply air lifts and pneumatic tools in the factory. All other power plant pumps and auxiliaries, except boiler feed pumps and exciters, are in the turbine room basement, thus simplifying the boiler room basement and also making the piping more compact and accessible.

Piping Shows Care in Design

Piping arrangements in the Leonard plant show care in design and attention to both safety and convenience of operation. In the boiler room, Figs. 4 and 5, practically the only piping, besides feed and blowoff connections, is the main header and the 16-in. exhaust line to the factory. The entire high pressure system is in the form of a loop, Fig. 5, running into the turbine room; connections for main turbines take off from one side of the loop and for the auxiliaries from the other side, with suitable cross connections and isolating valves and good provisions for draining the loop. All turbine room piping is below the main floor, presenting a pleasing appearance.

To carry exhaust steam to the factory, a 16-in. line runs below the main header in the boiler room and en-

Principal Power Equipment of Leonard Refrigerator Division, Electric Refrigeration Corporation

BOILERS AND COMBUSTION EQUIPMENT

Boilers....Wickes Boiler Co.
Type....Vertical water tube
Number....4 (1 under erection)
Heating surface, each, sq. ft....5083
Steam pressure, lb. gage....170
Superheat, deg. F....70-100
Superheaters....Foster Wheeler Corp.
Cyclone Grates....Cyclone Grate Bar Co.
Surface, sq. ft....77
Sawdust Feeders....Designed by Neiler, Rich & Co.; Mfgd. by Webster Mfg. Co.
Drive, vertical steam engine....Engberg's Elect. & Mech. Works
Furnace Arches and Walls....M. H. Detrick Co.
Furnace volume....1144 cu. ft.
Furnace volume, per sq. ft. heating surface....0.225

FUEL HANDLING EQUIPMENT

Fuel....Wood refuse supplemented by W. Va. coal
Scraper Conveyor over wood storage bins....Webster Mfg. Co.
Drive....5-hp. G. E. motor
Bucket Elevator for ash...Link-Belt Co.
Coal Storage Tank....Fitzsimmons Concrete Const. Co.
Type....Cylindical, concrete, 330-t.
Bucket elevator, coal...Leitelt Iron Works
Industrial cars, coal....Koppel Co.
Coal Scale....Fairbanks, Morse & Co.
Chimney....General Concrete Const. Co.
Type....Reinforced concrete
Dimensions..11 ft. I. D. at top, 175 ft. high
Breeching....Wickes Boiler Co. (Sil-O-Cel lined)

HEATERS AND PUMPS

Feedwater Heater....Cochrane Corp.
Type....Open, metering V-notch weir
Capacity....One, 90,000 lb. per hr. (3000 hp.)
Boiler Feed Pumps....DeLaval Steam Turbine Co.
Number....1
Type....2-stage, centrifugal
Capacity....200 g.p.m., 3000 r.p.m. 440 ft. head
Drive....DeLaval steam turbine, direct connected
Boiler Feed Pumps....1 old recip. pump which will be replaced
Pump Governors....The Swartwout Co.
Vacuum Pumps..American Steam Pump Co.
Number....2
Type....Reciprocating, simplex
Size, each....10 by 14 by 20 in.
Governors....Fisher Governor Co.
Service Pumps....Advance Pump & Comp. Co.; American Steam Pump Co
Number, Advance....1
American....1
Size, Advance....8 by 5 by 10
American....10 by 6 by 16
Governors...The Chaplin-Fulton Mfg. Co.
Fire Pump....Worthington Pump & Machy. Corp.
Number....One, 1000 g.p.m.
Air Compressors....Ingersoll-Rand Co.
Number....2
Type....Imperial, steam-driven
Capacity....One 823 c.f.m., one 400 c.f.m. at 100 lb.
Air Filters....Midwest Air Filters, Inc.

GENERATING EQUIPMENT AND AUXILIARIES

Turbo-Generators...General Electric Co.
Number....2
Type....Extraction, bled at 14.7 lb. abs.
Capacity....1250 kw., 3600 r.p.m., 3 phase, 60 cycle, 480 v.
Turbo-Generator....General Electric Co.
Number....1
Type....Non-condensing
Capacity....200 kw., 3600 r.p.m., 480 v., 3 phase, 60 cycle
Generating Set....Engine-driven
Number....1
Generator....Fort Wayne Electric Works, 25 kw., 480 v., 3 phase, 60 cycle
Engine....American Blower Co.
Exciters....General Electric Co.
Number....2
Capacity, each....35 kw., 125 v. d.c., 1800 r.p.m.
Drive....1 G. E. ind. motor, 1 G. E. non-cond. turbine
Motor-Generator Set..General Electric Co.
Number..One, 350 kw., synch. mot.-driven
Switchboards....Electric Const. & Machy. Co.
Circuit breakers and U-Re-Liters and aut. throwover....I. T. E. Circuit Breaker Co.

CONDENSING EQUIPMENT AND AUXILIARIES

Condensers (main unit)....C. H. Wheeler Mfg. Co.
Number....2
Surface, sq. ft., each....3000
Air Pumps....C. H. Wheeler Mfg. Co.
Number....1 per unit
Type....Radojet, int.-aft. condenser
Capacity....22.5 c.f.m. at 2 in. abs.
Circulating Pumps....C. H. Wheeler Mfg. Co.
Number....2 (1 per unit)
Capacity....3500 g.p.m., 32-ft. head
Drive....40-hp. G. E. motor
Hotwell Pumps...C. H. Wheeler Mfg. Co.
Number....2 (1 per unit)
Capacity, each....45 g.p.m., 60-ft. head
Drive....5-hp. G. E. motor
Condenser Expansion Joints....C. H. Wheeler Mfg. Co.
Cooling Tower..One, C. H. Wheeler Mfg. Co.
Capacity....3200 g.p.m. water from 105 to 85 deg. at 80 deg. air, 65 per cent humidity
Fans....Three, 12-ft. diam.
Fan drive....Allis-Chalmers Texrope drive from three 20-hp. G. E. motors
Pumps....Two centrifugal, 3200 g.p.m. each, 50-ft. head
Pump drive..40-hp. G. E. dir. con. motor

MISCELLANEOUS MECHANICAL EQUIPMENT

Air Conditioner (main gen. cooling air)....Spray Engineering Co.
Turbine Oil Coolers....General Electric Co.
Oil Purifier, centrifugal....DeLaval Separator Co.
Soot Blowers....Bayer Co.
Feedwater Regulators (S-C)....The Swartwout Co.
Water Columns....Wright-Austin Co.
Water Gages, marine type....Jerguson Gage & Valve Co.
Traps, hp....Boylston Steam Specialty Co.
Traps, vacuum....Warren Webster & Co.
Piping....National, installed by O. J. Dykman
Insulation....Keasbey & Mattison Co.
Valves and Fittings
Steam and water....Crane Co.
Non-return....Golden-Anderson Valve Specialty Co.
Atmospheric relief....G. M. Davis Regulator Co.
Pressure reducing....Boylston Steam Specialty Co.
Blowoff....Yarnall-Waring Co.
Exhaust heads....The Swartwout Co.
Atmos. rel. piping....American Spiral Pipe Works
Turbine Room Crane....Whiting Corp., 10-t.
Gratings and Stairs....Tri-Lok Co.
Damper Control....Hagan Corp.
Steam Flow Meters....Republic Flow Meters Co.
Thermometers, recording....American Schaeffer & Budenberg Corp.

larges to 18 in. in the turbine room, where it receives the exhaust from the auxiliaries and the extracted steam from the main turbines, Fig. 5. Just inside the boiler room, a riser on this line leads to the open feedwater heater, set above the boiler feed pumps in one end of the boiler room. Suitable atmospheric relief valves are provided on the heater and the usual connections through reducing valves admit live steam to the 16-in. line in case the supply from the turbines and auxiliaries is insufficient. From each condenser, a 16-in. pipe leads to a 24-in. relief header, provided with atmospheric relief valves, and the 24-in. header is run up to an exhaust head on the roof. The 200-kw. turbine and the 35-kw. exciter turbine also have emergency relief connections to the relief header.

Steam for the plant is supplied by three vertical water-tube boilers, each of 508 b.hp. capacity, set as shown in Fig. 4. A fourth similar unit, taken from the old plant, will be connected up in the near future. These units make steam at 170 lb. gage, 70-100 deg. F. superheat. A convection type superheater is set in the first pass of each unit.

Boiler blowoff lines from each boiler run to a blowoff header in the basement, the header discharging to a blowoff tank. Check valves between the blowoff valves and cocks at each boiler form a safeguard against accident in case a boiler is shut down, by preventing blowdowns from other boilers from entering the empty one. The blowoff header is placed in a passageway behind the boilers to give easy access in operating the valves.

Boiler feedwater makeup comes directly from the city mains and needs no treatment or purification. Vacuum pumps bring the returns back from the dry kilns and heating system and send them to a receiving tank, whence they flow down to the open feedwater heater, of 90,000 lb. per hr. capacity, set about 15 ft. above the boiler feed pumps in the boiler room. Hot well pumps discharge condensate from the condensers directly to the receiving tanks to mix with the returns. Since all this return water is used as boiler feed, raw makeup usually forms about 10 per cent of the supply.

Waste Wood Forms Principal Fuel

Fuel for these boilers consists for the most part of shavings, sawdust and hogged fuel. This wood refuse,

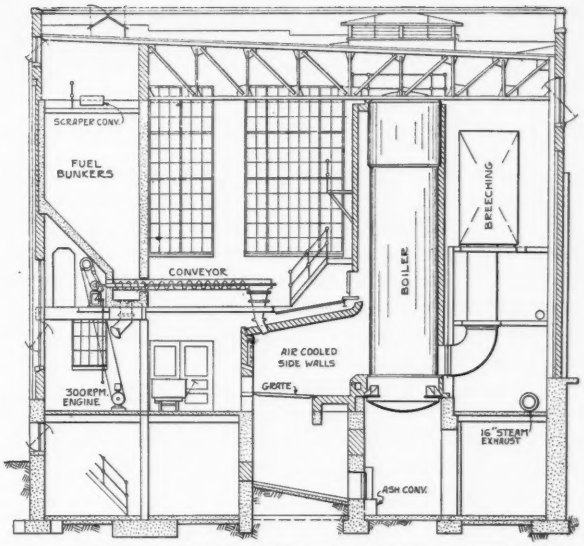


FIG. 4. SECTION THROUGH BOILER ROOM, SHOWING DETAILS OF FUEL FEEDERS AND FURNACES

blown from the factory to a cyclone collector on the boiler house roof (see headpiece), drops to a scraper conveyor that carries it to the concrete storage bunkers at the side of the boiler room. From these bunkers screw conveyors feed the fuel to the furnaces.

Screw conveyor feeders, of which there are two to each furnace, have a special construction, where they pass through the bins, designed to prevent jamming and congestion in case a large piece of wood comes through. In this section, the core of the screw consists of a 6-in. pipe and the screw has a 5-in. pitch, while outside the bins it has a 9-in. pitch. This reduces the speed of feeding into the screw and has been found extremely satisfactory. Once in a while, a large piece of wood comes through with the hogged fuel and causes arching in the bins just above the screw conveyor. A small air jet installed here has proved useful in eliminating this arching.

Conveyors are driven from a line shaft, which in turn is belt-driven from a vertical steam engine on the firing floor. The line shaft drives jack-shafts for each pair of screw conveyors; the jack shafts carry bevel

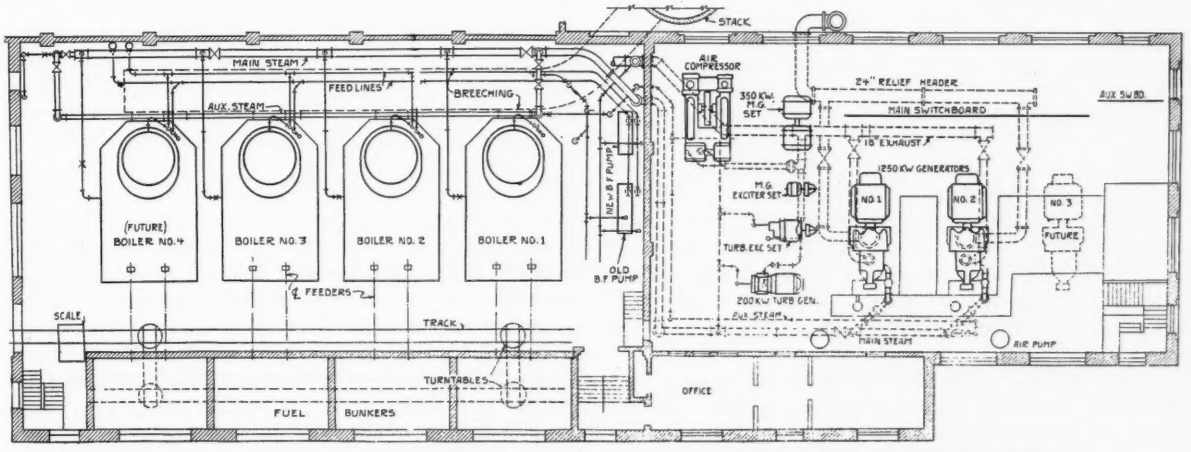


FIG. 5. GENERAL PLAN, SHOWING MAIN STEAM, EXTRACTION AND TURBINE RELIEF PIPING

gears driving the screws and each jack shaft can be started or stopped from the floor by a lever that varies the pressure of an idler against the driving belt from main shaft to jack shaft.

Ventilated Furnace Walls Supply Combustion Air

Fuel drops into the furnace, some of it burning in suspension and the remainder falling to the grates, Fig. 4. Supply of combustion air in woodburning furnaces is important and in this case has been provided for by ventilated furnace sidewalls. Air enters through openings above the suspended arch, either at front or back of the arch, passes to the sides, then through the hollow side walls and finally to the front wall, where it enters the furnace through ports above the grates. Natural draft is provided by a reinforced concrete chimney 175 ft. high, while an automatic control system regulates the dampers to give proper air supply for load and steam pressure.

In case the supply of wood waste is insufficient to meet the steam demand at any time, it is supplemented by 14,000-B.t.u. West Virginia coal fired on the grates by hand. This coal is loaded by a bucket elevator into a concrete storage bin outside the boiler house. From this bin, industrial cars bring it into the boiler house, where it is weighed on a track scale and then moved to the firing aisle. Later on, a monorail hoist will be installed to transport the coal from the storage tank. The company is also giving consideration to the installation of some sort of coal burning equipment in connection with the fourth boiler, to eliminate the present hand firing of coal.

Every effort has been made in this new Leonard power house to provide for economy of operation, safety and convenience, without undue elaboration. In many of its details, referred to above, the plant follows practices ordinarily found only in central station work and represents the latest design in the industrial plant field for using waste fuel and for supplying from extraction turbines a varying steam load that sometimes overbalances the electrical load. Besides this, the plant presents a pleasing appearance with its walls of cream brick, its well-painted equipment and its general cleanliness and air of good housekeeping. A. A. Dick, plant engineer, supervised the erection of the new plant and Roy Stratton, chief operating engineer, is now in charge of it. A. D. McCaughna is general manager of the Leonard Refrigerator Division. These men co-operated with Neiler, Rich & Co., consulting engineers of Chicago, who designed the plant.

Condensing Water Systems Vary with Location

Water Used for Cooling Purposes Must Be Suitable, Not Only in Temperature but in Freedom from Injurious Acids, Fish and Other Debris

INASMUCH as the choice of the location of a power plant is dependent in a great many instances on the availability of condensing water, considerable thought should be given to the manner in which this condensing water is handled through the plant. There are, of course, a great many factors which enter into the problem and no general rules can be given as to the exact equipment and arrangement which should be followed in all cases. As a matter of fact, each installation should be considered on its own merits as the possibility of increasing the efficiency of the plant, economy of construction and avoidance of trouble are almost as numerous as the variations in the topography of the land where plants are located.

While sea water is quite ideal for condensing purposes, it is not always the most convenient to get to a plant located near the sea shore. Where a plant is located on the shore where there is a beach, it is necessary to bring the water to the plant in tunnels or canals from considerable distance out into the sea, as the shifting sands are a considerable annoyance and inconvenience in condensers and intake tunnels.

On rocky coasts, however, this difficulty is not so apparent, but it is usually necessary to place the plant at a considerable elevation and the designer must choose between pumping the water from the ocean to the plant elevation or locating the condenser in a well near sea level.

Power plants using lake water for condensing purposes have somewhat similar problems as those encountered by plants along the seashore, to which, however, may be added in many cases the difficulties encountered with ice during the winter season. There is also likely to be a wider variation in temperature range of the water in lakes than in the ocean and while this does not affect greatly the intake arrangement, it does affect the efficient operation of the power plant and these changes must be considered in the proper proportioning of the equipment used.

For plants using river water for condensing purposes, the problems are considerably more varied than for those employing either ocean or lake water. Not only are there troubles due to sand, ice, fish and floating debris encountered in river water, but there are the problems of a shifting of the current of the stream from one side of the river bed to the other, the extreme variation in water level from drought to flood conditions, the troubles encountered with impurities in the water due to industrial plants discharging their sewage and waste products in the stream above the power plant and in some cases the necessity of recirculating the water due to an insufficient supply or to prevent freezing.

Experience has guided engineers to a more or less standard arrangement of equipment in the screen house and Fig. 1 is quite typical. Here the water passes first through a trash rack which may be either vertical or at an angle that will allow the floating debris to rise to the surface of the water. The object of this rack is, of course, to intercept debris of large size that might cause trouble farther on in the system. In some locations, mechanical means are provided to keep the racks clear, though this provision is not always essential as occasional cleaning by hand may be sufficient.

All debris that passes through the trash rack and is

too large to pass through condenser tubes is caught on a traveling screen and washed off into a trench by means of which the trash is carried away.

Due to the fact that traveling screens handle nearly every conceivable kind of floating material, the need for convenient means for keeping them clean is obvious and, for this reason, it is common in practice to place the screens in wells with sluice gates at the entrance and discharge openings. This arrangement gives opportunity for isolating the screen and cleaning out the well. To insure continuous water supply at least one spare unit should be provided. In many screen houses, cranes are installed for drawing the screens out of the wells. This is a convenience readily appreciated when repairs have to be made.

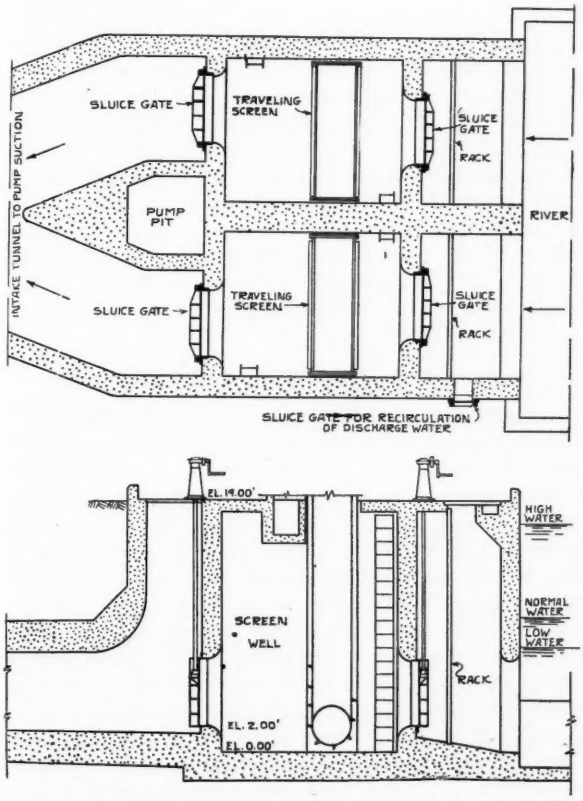


FIG. 1. TYPICAL ARRANGEMENT OF INTAKE PROVIDED WITH TWO TRAVELING SCREENS

All of these problems have been met at various times in different plants, and a little study of what has been done under various conditions will be instructive.

Plant at Lake Shore Uses Channel Across Beach

At the Bayside Station of the Wisconsin Public Service Corp., which is located on the shore of Greenbay at the mouth of the Fox River about 2½ mi. north of the city of Greenbay, Wisconsin, the problem of bringing in condensing water was complicated by the extent of the beach. The arrangement of the intake and discharge channels is shown in Fig. 2. Here it will be noted that condensing water is taken from the main ship channel through a dredged channel from a point north, or downstream, from the plant about 1300 ft. and is

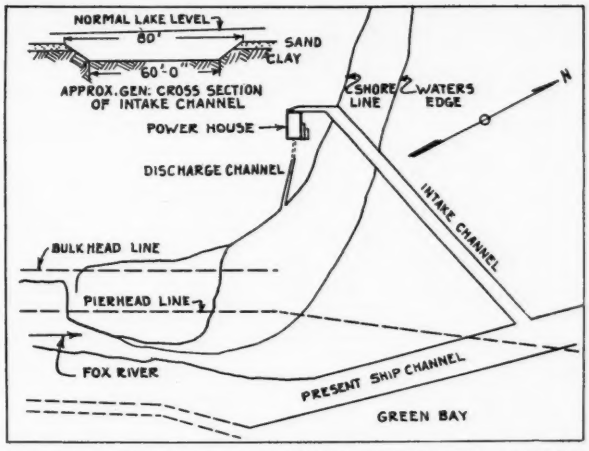


FIG. 2. AT BAYSIDE, A CHANNEL CUT ACROSS BEACH GIVES BETTER CONDENSING WATER

discharged upstream from the station. As the river is to some extent contaminated by the paper mills farther up and as the channel bears to the east at this point, it was felt that colder and purer water would be obtained in this way with less chance of condensers being fouled.

Spray Pond Supplements Creek Supply

One of the most unique condenser intake arrangements employed is that at the Whippany plant of the Jersey Central Power & Light Co., where the supply of river water is not at all times sufficient for condensing purposes. The arrangement of the intake and spray pond is shown in Fig. 3. For the installation of the spray pond a new channel was excavated for Whippany Creek and dammed with a permanent sheet tile dam to elevation 189.5. At the entrance to the old channel a coarse screen was erected. The channel was cleared for a considrable distance and then sloped rapidly to a sump for removing the sediment. Passing through the sump the water flows through two ⅜-in. revolving screens of 17,000 g.p.m. capacity; self-cleaning in that any refuse carried up on the screen is automatically washed off. From this screen the circulating water is fed through an intake and two 5-ft. concrete pipes to the two wells from which it is pumped to the condenser. It ultimately returns to the tank under the spray pond pump house. Here it is either released downstream to Whippany

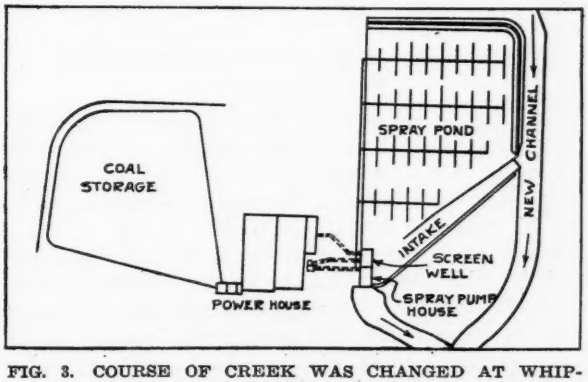


FIG. 3. COURSE OF CREEK WAS CHANGED AT WHIPPANY TO PROVIDE SPACE FOR SPRAY POND

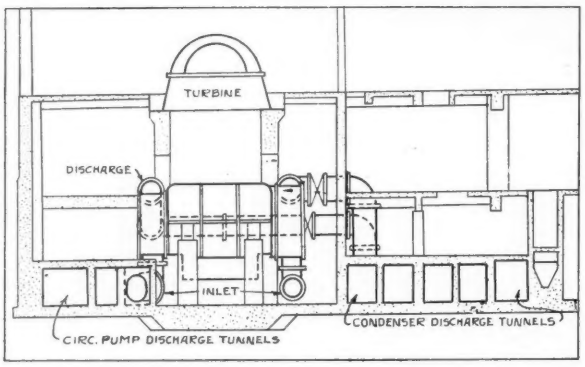


FIG. 4. ARRANGEMENT OF BRANCH TUNNELS UNDER CONDENSERS AT STANTON POWER STATION

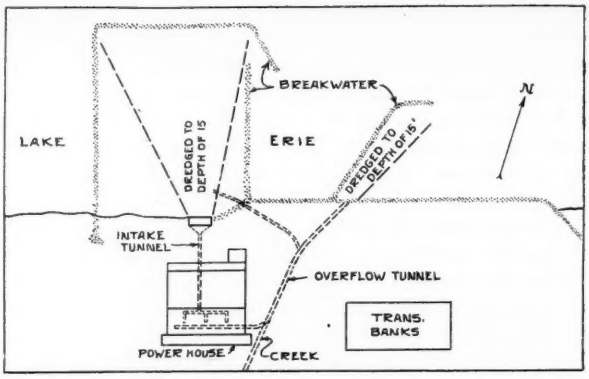


FIG. 5. SETTLING BASIN FORMED BY BREAKWATER RESORTED TO AT AVON

Creek or, if the water supply is low, pumped through the spray nozzles to the spray pond. Thus the circulating system uses all the water of the creek when below level 189.5 ft. and has a satisfactory source of supply arranged in even the dry season.

Circulating water for Stanton Power Station, located at West Pittston, Pa., on the Susquehanna River, is drawn from this river at the crib house through traveling screens and passes to the circulating pumps through concrete tunnels. These circulating pumps are not located under the condensers, but are in a pump room at the north end of the turbine room basement, where the intake tunnels enter the building. These tunnels enter at the center line and branch to the right and left parallel to the plane of Fig. 4. From these branches the circulating pumps take their suction and they discharge into the tunnels shown as circulating pump discharge tunnels. These are so laid out that in the ultimate plant one pump discharge tunnel will serve two condensers in each section, while there will be a circulating pump installed for each condenser.

In effect these form pressure tunnels to which the inlet pipes of each condenser are connected. As there is an inlet and discharge pipe on each water box, a simple manipulation of valves will release the flow through the condenser. The condensers discharge through other concrete tunnels leading back to the river downstream from the intake.

Besides the two circulating pumps, an ice melting pump is installed to recirculate discharged water to the cribhouse. The tunnels are arranged so that one pump can pump into two tunnels and in winter when the circulating water is cold, can serve two turbines.

Settling Basin Dredged to Supply Lake Water for Condensers

At the Avon Station of the Cleveland Electric Illuminating Co., with full load operation, the plant will ultimately require 420,000 g.p.m. of circulating water which is provided through an intake and settling basin 600 ft. wide and extending 700 ft. out into the lake, dredged to an average depth of 15 ft. The masonry enclosing this basin is constructed principally of sandstone block with the limestone core. As the circulating water is drawn to the condensers, it first passes a set of stationary trash racks into three 22-ft. revolving water screens, then 309 ft. through an underground tunnel 17 ft. in diameter to the distributing canal which runs under and parallels the turbine room basement. Branch connections from this canal supply the intake wells for each group of circulating pumps. After passing through the condensers, the circulating water is returned to the lake in a discharge tunnel, 14 ft. wide by 15 ft. high, which is arranged on the opposite side of the basement from the intake canal and runs the entire length of the room. In winter part of the discharge water is diverted through a bypass connection to the intake basin for the prevention of ice formation in front of the water screens.

Caring for Extreme Water Level Variation

Columbia Power Station, located on the Ohio River near Cincinnati, presented rather unusual condenser intake problems due to the extreme rise and fall of the water level in the river. Here intake and discharge tunnels, which are 5 ft. 6 in. by 13 ft. 2.5 in. with their bottoms 91 ft. below the turbine room floor, as shown in Fig. 6, were installed to care for the ultimate capacity of the plant, 360,000 kw. Water from the river enters the crib house through traveling screens, eight of which are installed, with room for a total of 16. These screens are 82 ft. 6 in. between vertical centers, and 6 ft. wide. Each screen is driven through reduction gearing by a 7.5-hp. slip ring induction motor. Stationary grids in front of the screens collect the larger debris, which is removed by a pivoted bucket crane using a 1-yd. bucket and having a lift of 95 ft. This crane is pivoted at the center of the screen house and the outer end travels around a semi-circular track. For maintenance work on screens a 35-t. crane is provided.

As the average variation is 64 ft. between high and low water of the Ohio River at the site of Columbia Power Station, the location of condensers and circulating pumps was, as previously stated, a matter of great importance. Accordingly a condenser well 77 ft. inside diameter and 85 ft. deep from the turbine room floor was constructed. The wall being of reinforced concrete 7 ft. thick. Two vertical inclined surface condensers for each unit are installed, exhaust connections to the turbines being made by the exhaust stack shown in Fig. 6.

On the floor of the condenser well are installed four 30,000 g.p.m. circulating pumps, two for each unit. When the water level is at its average point in the river,

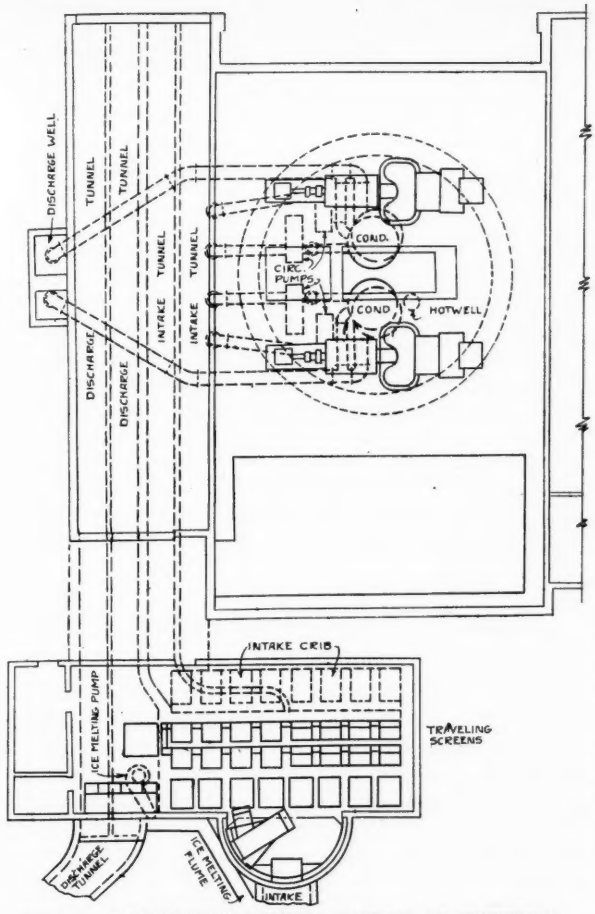


FIG. 6. CONDENSING WATER SYSTEM AT COLUMBIA

the water is practically flowing through the condensers, the pumps simply serving to overcome friction.

At the Kearny Station of the Public Service Production Co., another interesting arrangement of condenser water service has been worked out. The intake canals are built of reinforced concrete and extend from the face of the dock, passing through the foundation of the bunker and boiler houses to the suction chamber located beneath the turbine foundation. They are of rectangular cross section, 9 ft. 6 in. deep and 6 ft. 6 in. wide. Each intake canal is designed to furnish 88,000 gal. of river water per minute for condensing and other purposes, at a velocity of 3.2 ft. per sec.

The Hackensack River is subject to flow and tide variations; to secure a continuous supply of water,

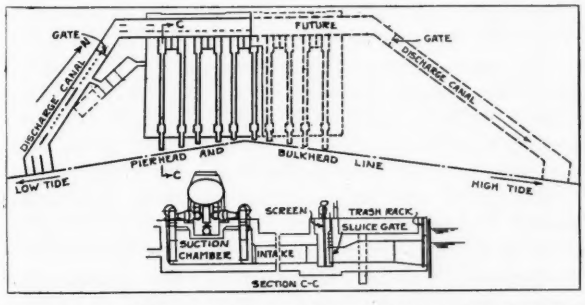
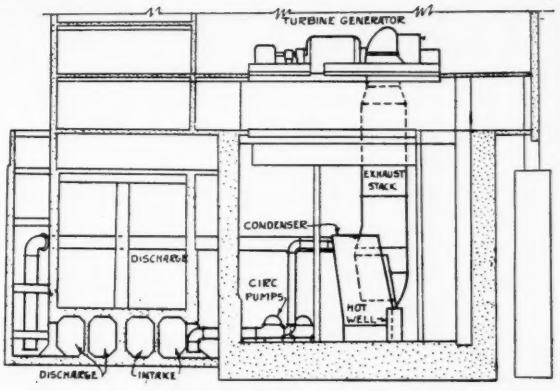


FIG. 7. INTAKE AND DISCHARGE CANALS AT KEARNY



irrespective of tide level, the under side of each intake canal roof is 2 ft. below the lowest recorded level. To prevent obstruction of water flow occasioned by coal barges tied to the dock, the face of the canal was brought back 4 ft. from the dock line. The position of these canals below the foundation mat of the station buildings made them integral with the foundations of the bunker house, boiler house and turbine room. The vertical walls of the canal act as ribs reinforcing the mat and distributing the load over the proper number of foundation tiles.

Each intake canal is provided with thrash racks at the entrance and with revolving screens located in the bunker house station. The screen wells can be isolated for cleaning and repairing by motor operated sluice gates. One canal has been provided for each unit with fixed canal installed as part of the initial installation for construction reasons.

The five generating units discharge their circulating water into a common canal proportioned to take the discharge and service water from a 10-unit station at a velocity of 3.8 to 7.5 ft. per sec., depending upon tide conditions.

The ultimate arrangement is to discharge the water into the river at either of two points, one upstream and one downstream from the point of intake so that the danger of recirculation may be eliminated. With the first half of the station, only the south or downstream section of the discharge canal system was built, but when the station is extended, the other section will be installed, and discharge control will be secured by the use of balanced segmental gates.

Occasionally the topography of the location is such that advantage can be taken of levels to do away entirely with circulating pumps. This is the case at Twin Branch, which result was obtained by utilizing the 24-ft.

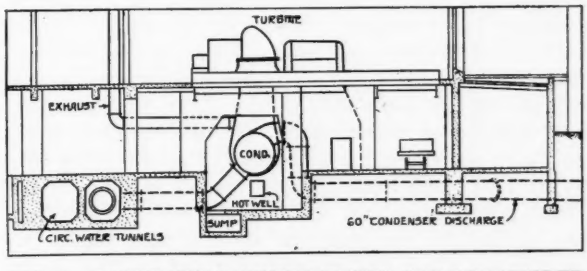


FIG. 8. CIRCULATING WATER PUMPS ARE NOT NEEDED AT TWIN BRANCH

head of water created by the dam at the existing hydro-electric plant in the St. Joseph River at that point. The top of the dam is at elevation 716 and the tops of the condensers were set at this elevation, producing an adequate flow of circulating water. It is estimated that the natural flow of the river regulated at this point by the dam will prove sufficient to supply condensing water for the ultimate 240,000-kw. plant. This arrangement of condensers at Twin Branch has obviated the need of

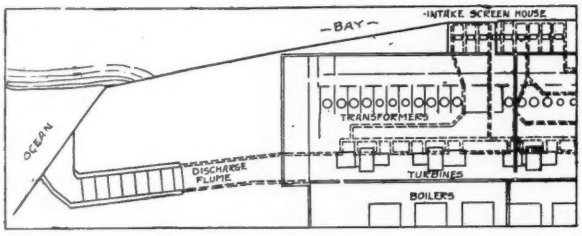


FIG. 9. WITH INTAKE FROM THE BAY AND DISCHARGE TO OCEAN, SEAL BEACH RELIEVES TROUBLE WITH KELP

a deep condenser well. The crib house is located on the river bank about 300 yd. from the power house, and contains the traveling screens driven by squirrel cage motors. From here the intake tunnel runs to the condenser pit and the water, after passing through the condenser, passes to a sealing well just outside the boiler house and then through the main discharge tunnel, emptying into the river again about 1000 ft. below the dam.

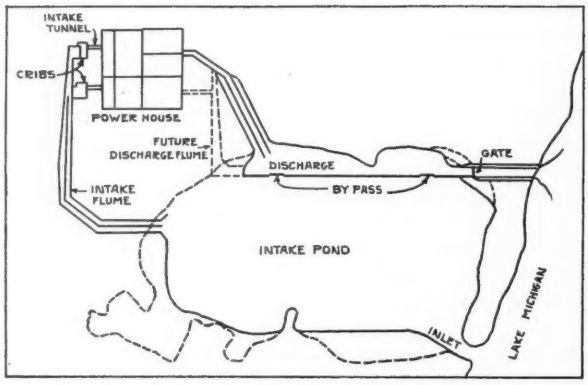


FIG. 10. INTAKE POND AT WAUKEGAN PROVIDES CONVENIENT MEANS OF RECIRCULATION

At the Seal Beach Power Station of the Los Angeles Gas & Electric Corp., circulating water is taken from the bay side of the plant through traveling water screens and pumped to the condenser by motor driven pumps. The discharge pipes from the condenser are sealed in the discharge tunnel so that a siphon is maintained at all times. The condenser cooling water is discharged to the ocean side of the plant, thus avoiding any tendency to recirculation. The ocean waters in this neighborhood contain great masses of semi-floating kelp which have caused considerable trouble in some of the plants which have been built to take water direct from the ocean. In selecting the site for this plant this feature was given due consideration and the location on the bay or inlet was thought of such a nature that this floating kelp would not be drawn into the intake. The arrangement of intake tunnel is shown in Fig. 9.

At the Waukegan Plant of the Public Service Co. of Northern Illinois, advantage was taken of the topography of the land to provide condensing water direct from the lake; at the same time arranging for recirculation in case of ice in the lake. Inasmuch as the circulating water is taken directly from the lake, the temperature is comparatively low. During the winter months it will probably average not much above 40 deg. F. There are, however, times in the summer when the circulating water temperature will reach probably 75 deg., although the average will be below 70 deg. During these periods when warm water only is available, the circulating pumps will be taxed to capacity. A small bayou has been provided into which, if necessary, in very cold weather, the circulating water discharge may be short circuited, thence directly through the intake flume and crib house to the pump suction. Normally, however, the cooling water is taken through the pond directly from the lake and the discharge is carried back into the lake.

"Test Weights" Made from Glass Bottles

DISCUSSING THE need for a simple and practical means of securing a satisfactory standard weight for use in checking accuracy of scales, C. A. Briggs, weight supervisor of the United States Department of Agriculture, told representatives of the National Scalemen's Association of a "useful and quite accurate weight that can be made from material generally available anywhere."

After a series of tests extending over 2 yr., Mr. Briggs has concluded that a satisfactory test weight, one that will remain sufficiently constant under varying conditions of moisture and temperature, can be made by filling ordinary bottles with shot or nails and closing them with corks and sealing wax. A set of such weights, calibrated to check with the Government standard, has varied less than 1 grain per pound during a 2-yr. period. When it is remembered that a pound contains 7000 grains, the degree of accuracy of these "bottle weights" is apparent. Their breakability is one of their chief virtues, for if hit, dropped or abused to such an extent as to affect their accuracy, they will generally break and be destroyed. Metal weights are often abused and retained in use when inaccurate.

ONE INDUSTRIAL engineer is a bit pessimistic about the wastefulness of the American people and fears we may need a serious, protracted business depression to restore us to sane working and thinking. Aside from wastes and lavish spending for luxuries in the home he lists, useless burning of electric lights, excess of oil and grease, leaking faucets and valves, broken pipe insulation, boiler tubes choked with soot, worn bearings, slipping belts, inaccurate meters as factors in the cost of carelessness and indifference to the American people.

Each item may be small but the total is a huge amount, which should be watched by executives or delegated to a trustworthy man whose job is maintenance of economy. Constant attention to these details pays continuous dividends.

Bleeding Large Turbines Practically Universal

NEW UNITS DESIGNED FOR BLEEDING, CASING OF MANY OLDER UNITS DRILLED FOR STEAM EXTRACTION. DESIGN BASED UPON BLEEDER OPERATION

AN ANALYSIS of replies to a questionnaire sent out by the N. E. L. A. indicates that turbines are bled at 1, 2, 3 and 4 points, not counting gland heaters. Older units naturally have a fewer number of bleed points. When economizers are used, the usual number of extraction points is two, and this same number will be used in extensions to present plants which will continue the use of economizers. The general tendency, however, is to increase the number of bleed points to three or four, while in one 1200-lb. pressure installation five points will be considered in future extensions. In many cases, it appears that the gain from heaters above the fourth frequently does not justify the added expense of this equipment and the operation of additional high-pressure heaters.

Invariably the reply to the question as to whether or not the turbine had been designed for bleeding or non-bleeding was that it had been designed for bleeding. This, of course, excepts the older turbines which were built for non-bleeding operation, but have since been drilled for bleeding.

Apparently these statements were based on the fact that certain bleed points were specified when purchasing and that the turbines were delivered with flange openings at these points. Attention is called to the fact that this alone is no assurance that the blade and nozzle dimensions are the most suitable and most efficient for bleeding operation. Many purchasers specify that the casing shall have a certain number of bleed points and also require guarantees to be made on the operation with no bleeding, so that the manufacturer would naturally design the blading in the proper proportion for the guaranteed conditions of non-bleeding operation.

TURBINES SHOULD BE DESIGNED FOR BLEEDING

Under these conditions the extraction of steam at the various bleed points in actual operation upsets the pressure distribution inside the turbine by lowering the pressure at the bleed stage and in all stages subsequent to this. This results in the lower internal efficiency for those sections of the turbine than would be the case if the blading and nozzles were designed for the most efficient operation with bleeding.

This loss persists through the whole operating life of the turbine and, while it is not of large magnitude, it warrants the insistence on a design based solely on operation with bleeding, even though this arrangement may present difficulties in testing, or may not give as high efficiency with no bleeding. A few turbines have been definitely designed for operation with bleeding.

As cases have been reported where the pressures at the bleed points of the turbine were not those guaranteed by the manufacturer, the questionnaire requested data on these subjects. Seven stations reported no data, seven reported the pressures in agreement with the guarantee, three plants stated that the actual pressures were considerably higher than the guarantee, while twelve stations reported that the actual pressures were generally below the guarantee, particularly at the first and second bleed points.

AS A RULE, THE ACTUAL PRESSURE AT THE BLEEDER POINT IS SOMEWHAT LOWER THAN THE GUARANTEED VALUE

Rated Capacity Kw.	Load Kw.	Initial Steam		Vac. Ins. Abs.	Absolute Pressure at Bleeder							
		Pres. Lb. Gage	Temp. °F.		No. 1		No. 2		No. 3		No. 4	
					Act.	Guar.	Act.	Guar.	Act.	Guar.	Act.	Guar.
10,000	10,000	325	676	1.50	3.67	3.39	16.4	18.2	....	....	....	....
20,000	10,200	....	....	1.53	2.38	2.30	9.1	9.1	....	....	....	....
20,000	16,000	325	624	1.08	3.25	2.98	13.6	12.1	51.0	51.4	117.0	....
22,500	22,500	295	618	....	3.9	5.2	17.4	20.0	....	....	....	....
25,000	20,000	351	662	1.03	3.8	4.75	12.8	15.6	56.0	62.0	103.5	....
30,000	22,000	270	630	....	11.4	12.0	38.2	40.3	....	....	....	....
30,000	30,000	260	650	....	3.9	4.1	8.1	9.9	....	....	....	....
30,000	30,000	235	665	1.00	15.6	16.7	9.5	9.6	....	....	....	....
30,000	30,000	295	668	....	8.7	8.4	41.5	39.1	....	....	....	....
32,000	32,360	365	692	1.06	2.46	3.7	23.3	26.1	....	....	....	....
33,000	32,500	351	688	....	2.05	3.48	....	37.5	140.0	136.0	....	....
35,000	35,000	250	600	1.0	7.12	6.8	50.3	53.5	....	....	....	....
40,000	30,000	250	606	0.9	3.8	4.5	8.7	9.0	35.8	52.9	....	....
40,000	40,000	586	720	1.0	7.6	7.3	38.2	40.3	....	....	....	....
45,000	43,500	597	700	1.0	2.8	3.1	9.5	9.6	....	....	....	....
50,000	36,000	289	615	....	7.6	8.0	51.8	51.0	....	....	....	....
50,000	40,000	266	657	1.27	3.86	4.33	15.7	17.0	....	....	....	....
50,000	42,000	406	672	0.7	3.15	4.21	17.45	21.2	56.9	56.4	97.6	98.1
50,000	47,500	384	713	....	2.83	3.22	8.14	9.9	....	....	....	....
50,000	52,450	564	664	....	4.2	5.1	22.6	20.5	113.0	118.0	....	....
52,000	49,210	554	708	....	3.46	3.6	15.6	16.6	47.6	48.5	....	....
62,000	57,000	551	717	....	3.2	3.23	9.14	9.75	31.2	31.4	....	....

Some of the data on various sized units are tabulated in the table, in order to indicate the variation of the actual pressures from the guaranteed pressures. These data are of great interest to operating engineers, for it is disconcerting to find that the feedwater temperatures in certain low-pressure heaters are lower than expected, as this, of course, means that greater amounts of steam than originally estimated must be bled to the high-pressure heaters. This decreases the expected efficiency of the turbine and increases the heat consumption of the station to a small extent.

Differences in Pressures Usually Fault of Design

Differences between actual and guaranteed pressures at bleed points may result in the effect of bleeding a turbine that has been designed for the best performance when non-bleeding, as already discussed. On the other hand, a manufacturer may not have analyzed his design to be able to predict accurately the steam at every point of expansion throughout the whole of the turbine, or he may have employed some method to predict the pressure he has guaranteed.

These practices are inexcusable in view of the accumulated knowledge of the actual performance of all types of turbines. If each manufacturer is given complete information of the specification of the bleeding service to be performed at each bleed nozzle, he should be able to guarantee with a fair degree of accuracy the probable steam conditions that will hold in service at each bleed point and should be able to secure pressures in the delivered turbines that will equal his guarantee.

Another factor is the drop in pressure between the stage, inside the turbine from which the steam is bled, and the bleed nozzle. Little data were submitted on this pressure drop but in several cases there appeared to be an unduly large drop at the first or low-pressure bleed point. In one case, this drop was reported to be 15 per cent of the internal stage pressure. This appears to be a matter of design, sufficient area not having been provided for the passage of the bled steam without throttling and it should be readily corrected on future designs. In one case, the size of the steam line from the bleed nozzle to the bleed heater had to be increased to cut down the pressure drop.

It is also probable that in certain cases unduly large quantities of steam must be bled from the third or fourth bleed points on account of lower pressure obtained at the first and second bleed points than were expected from the guarantee. These added steam volumes naturally increase the pressure drop in the steam lines, resulting in less heating of the feedwater there and requiring additional steam to be bled at the higher points. Such operation results in a slight decrease in overall plant efficiency, which may be avoided by proper design.

Extraction Heaters Result in Lower Heat Consumption

Naturally the use of bleed heaters results in a lower heat consumption than is possible without bleeding. Two plants reported that the most efficient load point had been raised by bleeding, while seven stations reported that the most efficient load point was reduced on the average of 5 per cent by the addition of two or more bleed heaters. This is what would be expected from a consideration of the design, particularly when turbines were proportioned for the best performance with no bleeding.

Some claim that one of the gains of bleeding is the removal from the working steam of a part of the water of condensation at the low-pressure bleed point. The subsequent stages should operate at higher efficiency so that the water removal can be effected. Little data had been collected on this point, although several companies report that they have been unable to effect any removal of the moisture. In one case it was reported that moisture is removed, or rather that operation indicates this as, when the wheel has been removed from the shaft, slight pitting was observed ahead of the bleeding point, but was not apparent on the next succeeding wheel. One company reports that the manufacturers of their turbine expected an appreciable saving to result from this separation of the water at the bleed point to such an extent that the moisture in the low pressure portion of the turbine would be reduced below the values that could be obtained with straight condensing operation.

Heaters May Be Left on When Starting Unit

Some stations start the turbines with the bleed heater shut off, the heaters being put in operation after the machine is put on the line. The majority of stations, however, leave the heaters in service during both starting and stopping and this practice appears to have no effect on the ease with which the operations were accomplished. If the heaters and the connecting steam piping are provided with proper drains that function by gravity and also with suitable vents, there seems to be no reason why they should not be considered integral parts of the main turbine unit.

When steam that would normally pass out to bleed heaters is made to expand in the turbine through to exhaust pressure, additional power will be generated, hence maximum capacity may be obtained in emergencies by shutting them off. Few companies report that they follow this practice. Several report that they have ascertained this increase to range from 2 to 10 per cent, while others report that they are unable to take advantage of this possible increase in output, due to limitations in electrical generator capacity.

No cases of flooding of turbines from tube ruptures or trap failures in heaters have been reported. Many devices, such as check valves, feather valves, automatic spill gates, electrically controlled valves and hydraulically operated valves are provided in the steam lines between bleed nozzles and heaters to prevent flooding should tube rupture occur.

In some cases the first low-pressure heater is dripped by an extra large sealed drop leg into the condenser. Valves, checks and other devices placed in the line between the bleed heater and the turbine casing may seriously increase the pressure drop between these two points, therefore, since it is desirable to secure full pressure in the bleed heater, design should be chosen which will produce the minimum pressure drop.

No difficulty has been experienced from steam flashing back into the turbine from the bleed heaters in case of loss of load. This is generally prevented by check valves or electrically controlled valves, although no difficulty has been experienced where these have not been used.

High Back Pressure Turbine in Rubber Plant

STEAM TURBINE TAKING STEAM AT 185 LB. AND EXHAUSTING AT 90 LB. IS INTERESTING FEATURE IN POWER PLANT SERVING A LARGE RUBBER PLANT

ALTHOUGH OVER three-fourths of the electric current used at the plant of the Seamless Rubber Co., at New Haven, Conn., is purchased from the local power company, the turbo-generator installation responsible for the remaining quarter of the current used is of considerable interest, because of the rather unusual conditions under which the turbine operates. This machine operates at 90 lb. back pressure.

A rubber plant of this kind, devoted to the manufacture of rubber goods of various descriptions, naturally has use for a considerable amount of high pressure steam for vulcanizing, cooking, moulding, etc., so regardless of whether electricity is generated or not, high-pressure boilers are needed.

Originally, all of the electric power used at this plant was purchased and steam for process work was supplied by 4 B. & W. boilers of approximately 400 hp. each. These boilers were operated at a pressure which varied anywhere from 120 to 150 lb. pressure—no attempt was made to keep it constant, since the pressure was reduced at various points in the factory to values suitable for the particular process involved.

Some time ago, it was considered feasible to generate a portion of the current used by a turbine, so a 400-kw. high back pressure turbine was purchased from the Westinghouse Electric and Manufacturing Co. and installed in the generator room. Mention of the generator room requires a word of explanation regarding the equipment installed in the plant at this time.

For the production of direct current two motor-generator sets were installed, each consisting of a 360-kw., 250-v. direct current generator driven by a synchronous motor and one a.c. to a.c. motor generator set for lights. These units were controlled from a vertical panel switchboard which also controlled the incoming a.c. power lines and the a.c. feeders to various parts of the factory.

This equipment together with the boilers was located on the second floor the ordinary factory building. The floor underneath the boilers had been built sufficiently heavy to support the boilers, but the floor supporting the motor generators was of ordinary factory construction.

When the new steam turbine was purchased, it was decided to remove the a.c. to a.c. motor generator set and install the turbine in its place. Preliminary studies made at the plant indicated that the boiler pressure should be increased to approximately 200 lb. and the superheat kept at 100 deg. F. The boilers were of sufficient strength to withstand this increase in pressure without any changes.

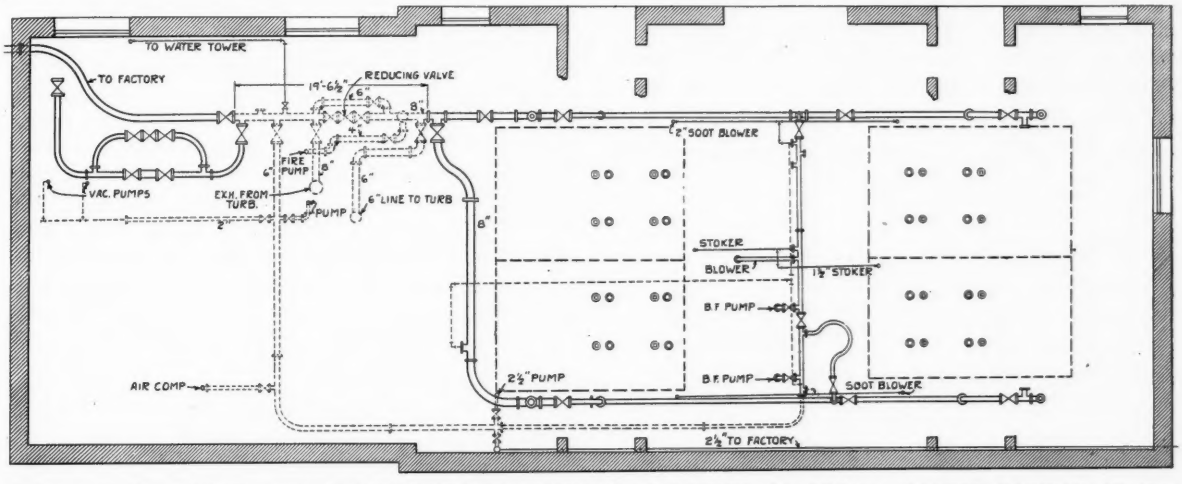


FIG. 1. PLAN SHOWING PIPING ARRANGEMENT IN SEAMLESS RUBBER CO. PLANT. DOTTED PORTION SHOWS NEW PIPING NECESSARY FOR TURBINE

The turbine generator unit consists of a 375-kv.a., 480-v., 3600-r.p.m., 3-phase, 60-cycle generator direct connected to a high back pressure non-condensing unit designed for steam conditions of 185 lb. pressure at the throttle, 100 deg. F. superheat and 90 lb. back pressure. A direct connected exciter of 14-kw. capacity generating current at 125 v. is part of the installation.

The manner in which this generating unit is operated with respect to the rest of the system is interesting. Because of certain stipulations in the contract with the local power company, the new generator is not permitted to be synchronized with the power company lines. The machine, therefore, has been arranged to feed into a separate bus, from which the factory lighting circuits are operated. In addition several power feeders are also arranged so that if the lighting load is low, they may be fed from the turbo-generator.

The arrangement can, perhaps, be best understood from the diagram shown in Fig. 3, which shows the elements of the electrical system. There are three buses; the turbo-generator bus, the main a.c. bus, and the d.c. bus. On the diagram is also indicated a small motor generator set operating in parallel with the turbo-

generator. This consists of a 75-kw., 440-v. General Electric a.c. generator direct connected to a 440-v. synchronous motor with direct connected exciter. This machine is used in several ways. It can be operated in parallel with the turbo unit to assist in carrying a heavy lighting or combined power and lighting load or it can be operated alone, when the turbine is shut down, to carry the lighting load.

Several power feeders are arranged to be fed from either the main a.c. bus or from the turbo-generator bus but interlocks are provided so that the generator cannot be paralleled with the a.c. bus through these feeders.

The installation of the turbo-generator was a matter which was fraught with many difficulties, since all the work had to be done without interrupting the operation of the plant for any length of time and with minimum disturbance to the existing piping.

Most of the auxiliaries, pumps, blowers, air compressors, etc., are located in the basement below the boilers and turbine room. The main steam lines were as shown by the full lines in Fig. 1. The boiler header system was looped. An 8-in. line delivered high pressure

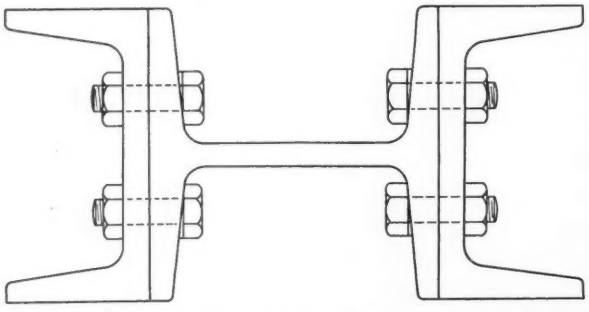


FIG. 2. METHOD USED IN STRENGTHENING COLUMNS

steam to the factory. When the new turbine was installed, a section of the line was removed and the system of piping shown by the dotted lines Fig. 1 installed. A 6-in. high pressure line, it will be noted, leads to the turbine and an 8-in. exhaust extends from the turbine to the low pressure side of the reducing valve. This reducing valve is used to supply 90-lb. steam in excess of that delivered by the turbine.

In installing the turbine because of the auxiliaries in the basement and the piping, a concrete foundation could not be used, so a steel framework was constructed which was supported on the vertical building columns.

It was found upon calculating the necessary strength of column supports for the turbine that the existing columns under the turbine room were not heavy enough, so before they could be used they had to be strengthened. This was done by bolting heavy channels to the sides of the existing I beam columns as shown in Fig. 2. Horizontal girders were then supported between each pair of vertical supports, and the actual turbine supporting members were placed at right angles on top of these. In order to gain sufficient mass to absorb vibration in the turbine, the space between each pair of supporting members was filled with concrete.

Most of the auxiliaries in this plant are operated from the 90-lb. steam main. These consist of a fire pump, two boiler feed pumps, two forced draft blowers, two stoker engines, one 1800-lb. hydraulic pressure pump, one 600-lb. hydraulic pressure pump and one steam driven air compressor. With the exception of one of the forced draft fans which is motor operated, all the foregoing auxiliaries are steam driven. There are also several motor driven auxiliaries. The main auxiliary steam line, it will be noted, is taken off the main steam header at a point just beyond the exhaust

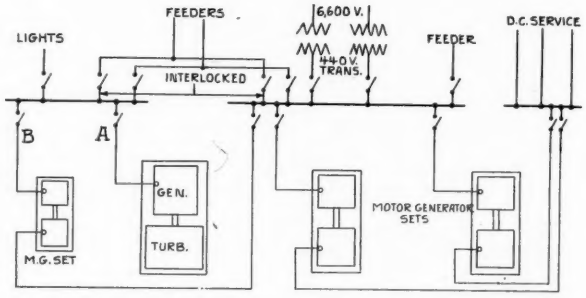


FIG. 3. DIAGRAMMATIC SKETCH SHOWING PRINCIPLES OF ELECTRICAL SYSTEM

connection from the turbine. At a point underneath the boiler room, this auxiliary header is connected to the old auxiliary header which connects to the high-pressure steam main. Normally the valve between this line and the high-pressure main is kept closed, but in case of emergency this valve can be opened and the auxiliaries operated from the high-pressure line.

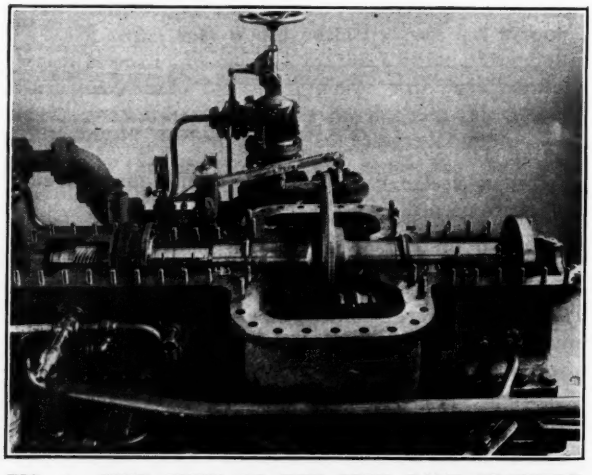


FIG. 4. SHOP VIEW OF THE HIGH BACK PRESSURE TURBINE INSTALLED AT SEAMLESS RUBBER PLANT, SHOWING CONSTRUCTION

The installation of the new turbine, during the time it has been operated, has fully justified itself by the savings effected through its use. On the average, this has run from $800 to $1000 a month.

The engineering problems involved in the installation of the unit were worked out under the direction of Mr. Saunders, Mechanical Superintendent of the Seamless Rubber Co., and the plant is operated by W. P. Smith, Maintenance Engineer.

New Boiler Added to El Paso Plant

TEMPERING OF COAL AND DRAFT CONTROL SYSTEM ARE FEATURES OF THIS TEXAS PLANT. BY JOHN U. MORRIS*

EL PASO, long thought of as nothing more than an overgrown cattle town, has now bloomed into a first class city with a population close on to 100,000 and rapidly increasing. There are old residents still living who remember one of the main city streets as a trail traversed by the pioneers on their way westward.

Load demands were quite in keeping with the growth of the famous border town and it was evident a year ago that the El Paso Electric Co. would need an additional boiler for the coming winter load (now just passed).

The first shipment of steel for the building extension was received on July 6 and 112 days later the boiler was delivering steam under regular operation at 250 per cent rating. A new coal handling equipment was also required to replace the old.

Besides the new boiler the plant equipment consists of eight Babcock and Wilcox 600-hp. (3-drum type) boilers and three turbo-generators that are in regular operation. There are two other small turbines that are held for emergency use only. The new boiler makes the ninth, is 1066 hp. and of the cross-drum type with all the modern "fixings," viz., water walls, air preheaters, hydraulic operated ash gates, induced and forced draft fans with special remote control, secondary air ducts for removing filtration losses in the ash pit, primary ducts for combustion control, and Diamond Valv-in-Head soot blowers. It might also be added that while the boiler is rated at 1066 hp., there is an additional heating surface of 888 sq. ft. in the water walls which brings the actual horsepower up to 1155.

The boiler is designed for 400 lb. pressure; but until such time that they may need to put in a new high-pressure turbine or remodel the latest installed unit, the boiler will be operated under 210 lb., as are the present eight.

Lack of sufficiently cold circulating water and the resulting higher back pressure on the prime movers, make efficiency rather low, so fuel economy in the boiler room is quite an important feature.

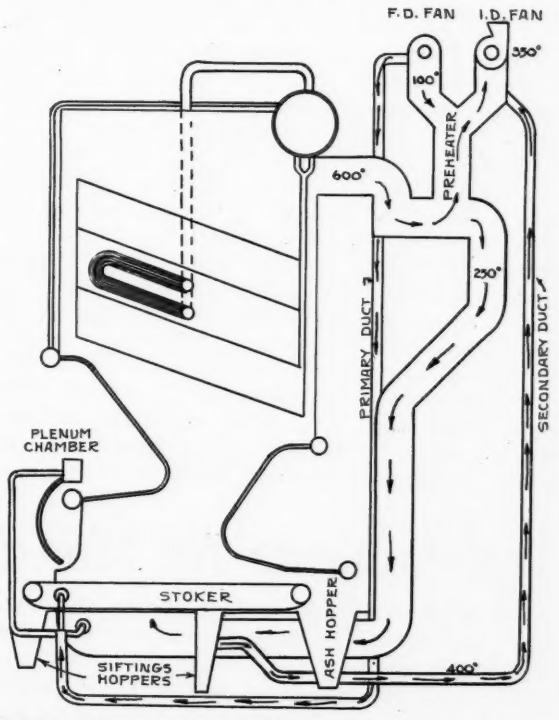
Coal for the El Paso Electric Co.'s plant comes from either Socorro or Corrillos counties in New Mexico. Taking all things into consideration, the former is fairly good steaming, especially for coal in the 12,000-B.t.u. class. Due to the dry climate surface moisture, except immediately after a rain, is practically nil and crushing the coal is more or less a necessary evil. The required amount of crushing is invariably too fine for most of the particles and unless the coal is dampened with water a good portion of the fines will pass through the boiler and stack without ever being burned. In other words, the fines are too fine for burning on the stoker and slightly too coarse to burn in the combustion space in the same manner as pulverized fuel.

This difficulty was solved several years ago by the operating force when they decided to try wetting the coal. It was a complete success and netted from three to five per cent in fuel saving. They have not had time to see if the added moisture makes as big a saving in the new boiler as it does in the old plant. Most likely it will not quite, for to all appearances the preheated air seems to ignite more readily some of the fines that formerly went up the stack.

Water added to the coal is metered and adjusted so that the coal as fired will run about 6 to 7 per cent moisture. The operating company has its own laboratory in the plant and samples are analyzed regularly.

COMBUSTION CONTROL SYSTEM

Among the new features interesting to the power plant engineer, is the combustion control. Products of combustion leaving the last pass (under the main steam drum and out through the down comer nipples) enter the air preheater tubes, thence to the induced draft fan and up the stack. Combustion air is taken from the floor and delivered to the outside of the preheater tubes and then discharged through ducts to the windboxes of the stoker.



CROSS SECTION OF BOILER SHOWING AIR SUPPLY SYSTEM

Between the induced draft fan and the preheater there are two 12-in. branch connections known as the secondary air ducts. These drain hot gases and air from the siftings hopper. Its function is primarily to create a down draft on the underside of the chain grate, thus blowing off the fine ash into the hopper and eliminating

*Master Mechanic, Stone & Webster, Inc.

to some extent the air losses in the ash pit by intercepting the cold air which invariably filters through the underside of the grate to the ash hopper.

Between the forced draft fan discharge and the preheater there is another connection (16 in.) known as the primary air duct. This bypasses the heater and is led to three places, namely, the windbox compartment, the first zone under the grates, and the plenum chamber over the Detrick arch. From the latter the air is led through nozzles to the ignition arch for an overfire draft.

While new in modern plants, this latter idea is old. The writer remembers one installation some 15 yr. ago in San Francisco. It was an overfire draft and designed principally to stop smoke, which it did successfully.

All different duct lines are dampered and the controls for them brought to an operating lever on the boiler room floor.

Returning again to the coal, some clinkering of the fuel and ash has been experienced on the test runs, but little as compared to the old boilers not having any water walls. A particular advantage in the case of No. 9 boiler is the fact that the lower header of the side water walls is on a level with the grates and performs more or less the same function in regard to clinkering as the side boxes did on older types of Babcock and Wilcox boilers.

Slagging and clinkering with this kind of coal, however, seems to take place above the fire and not on the grate at all. Small particles of incandescent slag are carried up with the flame and deposited on the walls for several feet above the fuel bed. In the case of the new boiler, most of the slag banks up on the rear water wall at the bend and a little on the side walls. In the old boilers this slag was carried up as high as the tubes and deposited on the lower row of generators.

Coal generally used runs around 51 per cent fixed carbon, 33 per cent volatile matter, 15 per cent ash, and nearly 1 per cent sulphur. Adding some 7 per cent moisture brings the fixed carbon down to about 47 per cent, volatile matter 30 per cent, ash about 15 per cent, etc. Due to particular care in design of the gas passages, preheater, etc., it is not expected that the sulphur will cause any appreciable amount of corrosion in the system, due to the formation of sulphuric acid.

The general design of the Green stoker seems particularly well adapted to this coal. The grates are close together and offer a well distributed air blast as well as slight chances of the fines sifting through.

At the same time the boiler was installed, a new coal handling arrangement was necessary. It is a Stephens-Adamson installation throughout. The coal is unloaded from the cars onto a track hopper, thence through a reciprocating feeder to a crusher, located directly underneath. A concrete pit some 30 ft. deep was built especially for this equipment.

From the crusher it is delivered to a rubber belt and up an 18-deg. incline to a transfer tower. At this point, the coal can be either discharged to another belt running at right angles and on to the station bunker or out to the cushion pile and there delivered by the drag line to the storage space. The drag line operates from the cushion pile to storage and from storage to the track hopper, or from track hopper to storage when necessary.

The present installation consists only of one track hopper and conveyor belt, but the buildings and other equipment are all arranged for a duplicate system which will allow an ultimate capacity of 200 t. an hour. The present layout will deliver 100 t. an hour.

The bunker for the new boiler is directly over the firing aisle and a traveling weigh-larry distributes the coal to the stoker hopper.

As previously stated, all combustion controls are brought to the operating floor level and metering equipment is located at the front of the boiler beside gages, etc., all of which go to make an especially accessible unit from the operator's standpoint.

An outline cross section of the new boiler is shown on the accompanying sketch. The general temperatures shown are for operation at about 200 per cent rating.

Instruments for Measurement of Temperature

ALTHOUGH INHERENT INSTRUMENTS ERRORS ARE USUALLY BELOW THE AVERAGE EXPERIMENTAL ACCURACY OF OTHER DATA, EXTREME CARE MUST BE USED IN THEIR LOCATION AND INSTALLATION

TEMPERATURE measuring instruments, as a whole, are considered the most accurate of power plant performance equipment. Inherent errors in the instruments themselves are small, much below the experimental accuracy of other data, but errors that arise from improper location and use are often serious.

Temperature measuring instruments, thermometers and pyrometers may be classified into several groups. The name pyrometer is usually given to those instruments adopted for use in measuring high temperatures. The following commercial types are available.

(a) Glass thermometers, with mercury, alcohol, pentane, or other organic liquids.

(b) Pressure-gage thermometers, with vapors or liquids as the actuating fluids. There are two classes of these thermometers:

(1) The vapor pressure type partially filled with liquid ether, sulphur dioxide, ethyl, chloride, methyl chloride, etc., and

(2) Those completely filled with a liquid or a gas, such as mercury, alcohol, nitrogen, etc. Instruments of the first type have scales that are made up of non-uniform divisions, while instruments of the second type have uniformly divided scales.

(c) Differential-expansion thermometers or pyrometers in which the differential expansion of two solids is used as an indication of the temperature.

(d) Electrical-resistance thermometers with which temperatures are determined by measuring the resistance of a calibrated wire.

(e) Thermocouple pyrometers, or pyrometers in which the electromotive force set up at the junction of two dissimilar metals is used as an indication of temperature.

(f) Optical pyrometers, with which temperature is determined by matching the luminosity of the hot body with that of a calibrated source or by other means which utilize the visible radiation emitted from a hot body.

(g) Radiation pyrometers, with which temperature is determined by absorbing radiation of all wave lengths upon a small body and determining the temperature of the source by the temperature attained by the absorber.

(h) Fusion pyrometers, with which temperature is determined by noting which of a series of materials with graduated fusion temperatures melt or soften when exposed to the temperature under investigation.

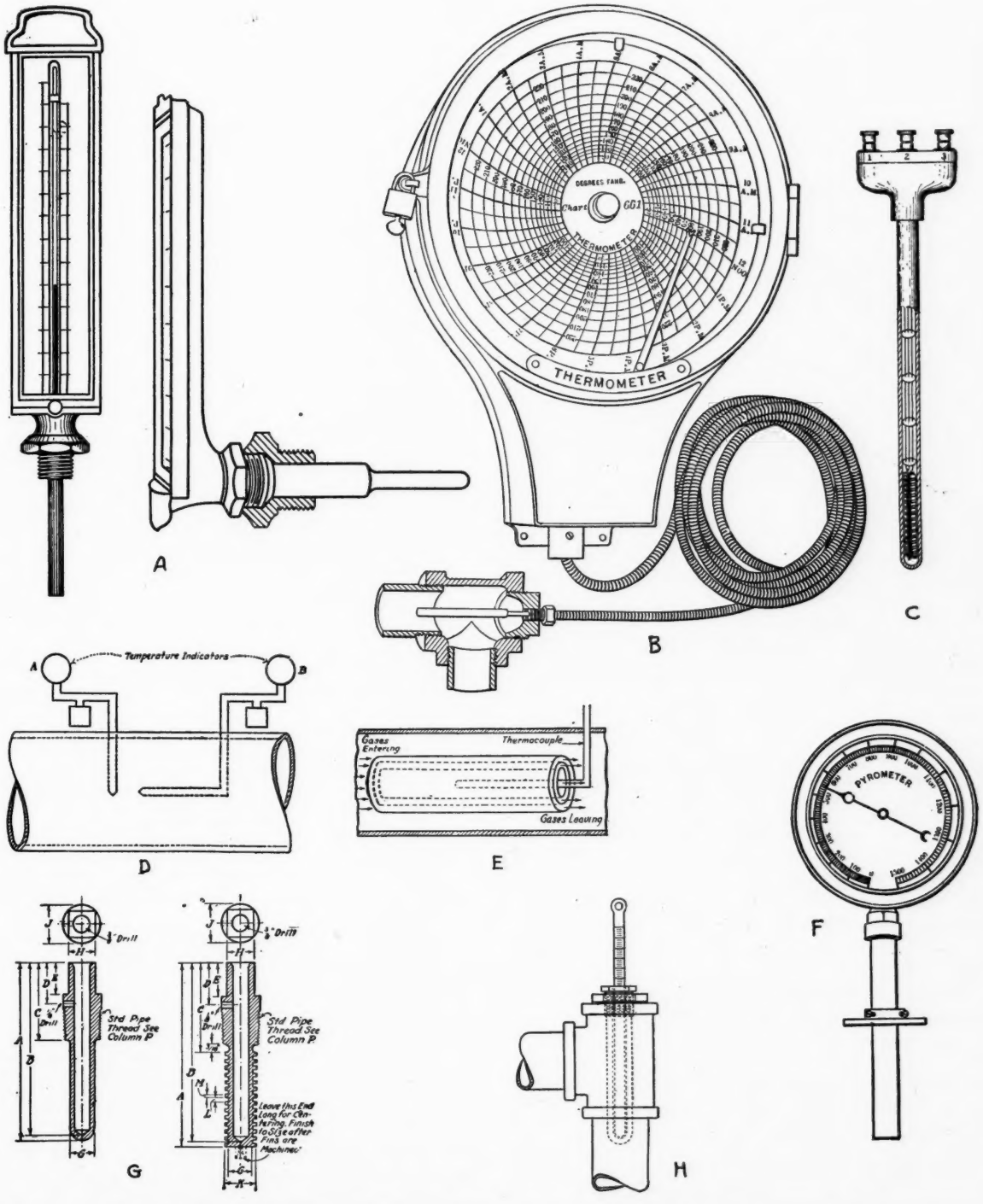


FIG. 1. A. COMMERCIAL TYPE MERCURY THERMOMETERS, B. LIQUID FILLED RECORDING THERMOMETER, C. RESISTANCE THERMOMETER BULB, D AND E. ILLUSTRATING PROPER INSTALLATION AND THERMOCOUPLES FOR TEMPERATURE MEASUREMENTS OF GAS, F. EXPANSION PYROMETER, G. TYPE OF THERMOMETER WELL RECOMMENDED BY A. S. M. E., H. INSTALLATION OF THERMOMETER WELL IN SMALL PIPES

(i) Calorimetric pyrometers, with which temperature is determined by noting the quantity of heat removed in bringing a body of known thermal capacity from the temperature to be measured to some lower known temperature.

(j) Color-temperature charts, with which temperature is estimated by comparing the color of a luminous hot body with colors given on the chart.

The range and accuracy of good commercial instruments when properly installed and used as given by the A. S. M. E. Power Test Code as shown in the table and several types of temperature measuring instruments are illustrated in Fig. 1. One of the most common sources of error arising in the measurement of gas and air or vapor comes in connection with radiation from bodies hotter or colder than those being measured, or, from the conduction of heat from or to the thermometer well from hotter or colder bodies.

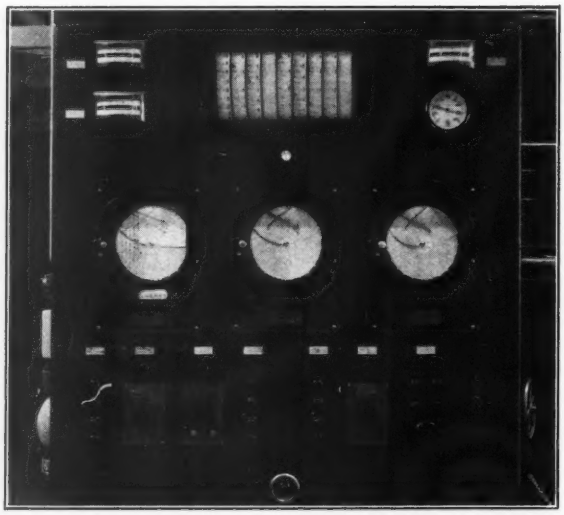


FIG. 2. A WELL ARRANGED BOILER CONTROL PANEL

Three methods of installing electric pyrometers to guard against this radiation error are shown in Fig. 1D and 1E. Thermometer wells of the type shown in Fig. 1G are recommended by the A. S. M. E., plain wells for use with liquid and saturated vapor and finned wells with gas and superheated vapor. The fins compensate more or less for the low rate of heat transfer from the gas to the bulb within the well for dry gases as compared with the rate of heat transfer from liquid to the bulb.

When the temperature is low and where the temperature variations are small so that the temperature lag due to poor thermal conductivity is negligible, oil may be used for filling the wells. The most satisfactory materials, however, are mercury up to 500 deg. F., solder from 500 to 1000 deg. F., and tin from 600 to 1800 deg. F.

Pressure Indicating Instruments Are Accurate

Pressure measuring instruments are available in both indicating and recording types, a few of commercial instruments being illustrated in Fig. 3. Pressure measuring instruments for draft service are usually made in the multipoint type, illustrated in the boiler control panel in Fig. 2.

As a rule, recording instruments of all kinds are to be preferred for all important locations as they give a permanent record of conditions which can be filed and analyzed when desired. Properly maintained and calibrated occasionally, they are more reliable than periodic readings placed on the log sheet from indicating instruments as they not only eliminate the human element with its corresponding possibility of error, but give the record of condition at all times so that in case of accident or poor operation these records are available for a thorough analysis of conditions.

ACCURACY THAT MAY BE EXPECTED WITH DIFFERENT TYPES OF COMMERCIAL INSTRUMENTS

Type	Range, deg. fahr.	Accuracy, deg. fahr.
(a) Glass Thermometers:		
Ordinary glass, mercury-filled	−38 to 575	1 to 2
Jena glass, mercury and nitrogen-filled	−38 to 1000	2 to 10
Quartz glass, mercury and nitrogen-filled	−38 to 1000	2 to 10
Ordinary glass, alcohol-filled	−100 to +100	0.5 to 2
Ordinary glass, pentane-filled	−300 to +70	0.5 to 2
(b) Pressure-Gage Thermometers:		
Vapor-Pressure Type:		
Alcohol-filled	200 to 400	2 to 10
Ether-filled	100 to 300	2 to 10
Sulphur-dioxide-filled	20 to 250	2 to 10
Liquid-Filled or Gas-Filled Type:		
Alcohol-filled	−50 to 300	2 to 10
Mercury-filled	−38 to 1000	2 to 10
Nitrogen-filled	−200 to 1000	2 to 10
(c) Differential Expansion Thermometer	300 to 1000	Uncertain
(d) Electrical Resistance Thermometer	−300 to 1800	Depends upon indicating instrument. 0.001° to 10°
(e) Thermocouple Pyrometers:		
Base metal	−300 to +2000	Depends upon indicating instrument. 0.02° to 20°
Rare-metal	0 to 2800	Depends upon indicating instrument. 0.1 to 20°
(f) Optical Pyrometers	1100 up	5 to 10 for black-body conditions
(g) Radiation Pyrometers	300 up	20 to 30 for black-body conditions
(h) Fusion Pyrometers	1100 to 3600	20 in best makes
(i) Calorimetric Devices	100 to 2500	Uncertain
(j) Color-Temperature Charts	800 to 2900	Uncertain

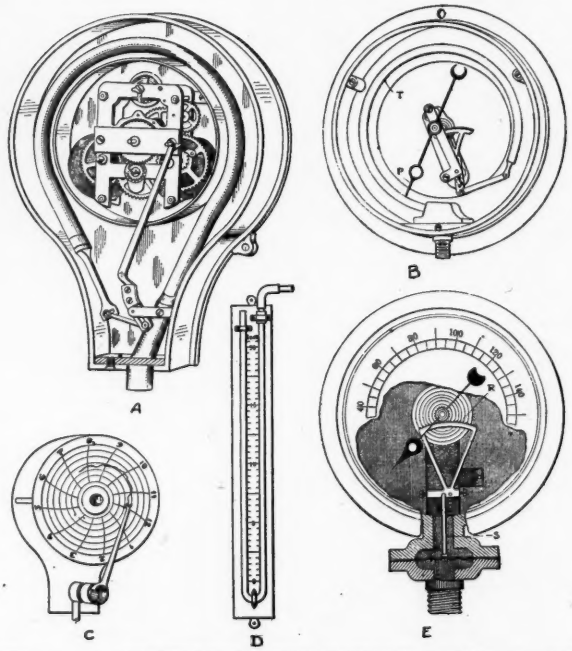


FIG. 3. A. RECORDING TYPE BOURDON GAGE, B. INDICATING TYPE BOURDON GAGE, C. RECORDING GAGE SHOWING DIFFERENCE IN SIZE AND TYPE OF EXPANSION TUBES, D. MANOMETER, THE SIMPLEST FORM OF PRESSURE MEASURING DEVICE, E. DIAPHRAGM GAGE

Temperature Limits in Central Station Operation*

A Discussion of the Properties of Metals at High Temperatures with Data on Alloy Steels Suitable for Use at 1000 Deg F. By V. T. Malcolm†

MUCH THOUGHT has been given to the use of increased temperatures in central station operation but engineers have hesitated to design high temperature stations because of the alleged inability of metals to withstand temperatures above 750 deg. F.

Materials are certainly available for use at 1000 deg. F. and while there is room for a difference of opinion in the matter it is hoped that as a result of discussion of the subject, the engineer will give serious thought to the use of metals at temperatures above 750 deg. F. as certain manufacturers of equipment are only waiting for him to decide.

As pointed out in an editorial in The Engineer (London) March 11, 1927, progress is hampered by the inevitable inertia of established practice, and practice has settled down to a maximum of 750 deg. The belief is prevalent that the engineer is only waiting for the metallurgist to discover some new and wonderful alloy that is heat resistant. This attitude hampers progress and it is much more to the point to make the best use of such metals as we have and to believe that progress is still possible with existing metals.

In a paper presented before the International Union of Producers and Distributers of Electrical Energy at the Rome, Italy, convention in 1926, A. E. Rubea, superintendent of the Gennevilliers Station in Paris stated that manufacturers of power plant equipment in France are ready to accept contracts up to 850 deg. F. and are preparing for further advances in temperature.

It is the author's intention in this paper simply to set forth certain facts which should be borne in mind when considering the use of metals at high temperatures. Before the engineer can do much in the design of high temperature stations, he must know the facts concerning metals at the temperatures he has in mind.

Physical Properties of Materials Suitable for High Temperature Service

The first and most important of the engineering problems awaiting solution is that of strength and elasticity of metals at high temperatures. We know that methods of test as applied to metals at ordinary temperatures are misleading when used in high temperature investigation because of the softening effect produced at high temperatures. We know that for every stress, no matter how small, there is a corresponding strain or deformation in the body acted upon, which strain increases as the stress is increased. The stress and corresponding strain are directly proportional up to a certain point, which is the limit of proportionality, below which by removing the stress the corresponding strain will disappear and the metal is said to be "elastic." It must be remembered, however, that the limit of proportionality depends upon the sensitiveness of the instruments used and the accuracy used in carrying out the test. When a metal is deformed beyond the proportional elastic limit, it is said to be overstrained. From tests such as these, the important characteristics from which designs may be calculated, may readily be determined.

When the same tests are applied at high temperatures, it is found that ordinary steels no longer possess the same elasticity and as the temperature is increased, the yield point loses definiteness and finally vanishes altogether. Fracture, too, occurs at a much lower temperature and more readily if the test is carried out slowly than at a rapid rate.

If a load applied at any particular high temperature is gradually reduced, a stress is reached at and below which no "creep" or flow is produced, no matter how long this stress is maintained. The author's investigations have shown that there is a critical stress at each temperature at which the metal may "creep" and that it continues to deform under continuously applied load; but in time this "creep" will drop to zero and continue there while above this stress the metal will creep rapidly until final fracture.

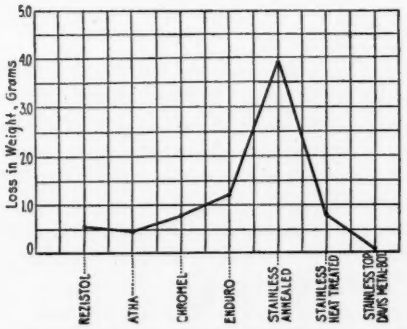


FIG. 1. RESULTS OF WEAR TESTING ON SEVERAL ALLOYS

(Wear tests of two 2-in. by 1-in. specimens sliding on each other under a load of 100 lb. per sq. in.; 4000 strokes.)

Therefore, it is the author's belief that at each temperature of the metal tested, there is a stress which if exceeded will cause fracture, though equipment may give satisfactory operation at this temperature with loads greater than the critical stress for many years.

In summing up the results of creep tests, three distinct types of stress may be noted:

1. A creep stress at which the flow of metal may be quite great.
2. A creep stress which shows a certain amount of deformation—up to 3 per cent.
3. A creep stress or critical stress at which no appreciable creep takes place.

The correct determination of the creep stresses is most useful in providing the engineer with data on which he may base his designs. The results shown by the creep test may appear very low, but they are safer designing stresses.

*Abstract of a paper presented at a meeting of the Metropolitan Section of the A. S. M. E., New York.

†Metallurgical Engineer, The Chapman Valve Mfg. Co.

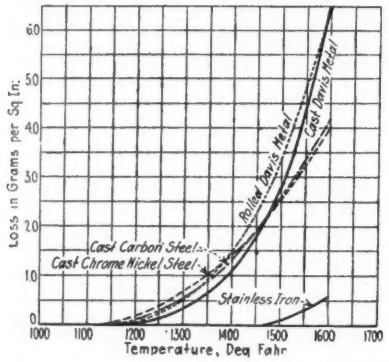


FIG. 2. SCALING TESTS AT HIGH TEMPERATURES ON VARIOUS MATERIALS. LENGTH OF TEST, 100 HR.

In the author's opinion, from the results of these creep tests, a relation will be established between them and the short time tests which will provide the engineer with a rapid method of determining the strength of metals at the elevated temperatures to which they will be subjected in service.

His present conclusions are that the design of equipment must be based upon the strength of metals at operating temperatures, over periods of long time, and that other properties such as thermal expansion, thermal conductivity, and chemical stability must receive greater attention than in present engineering practice. These latter factors will probably govern actual design, but the first and basic requisite is that of physical strength at the proposed temperature.

Chemical Stability

Problems of corrosion at high temperatures, while not so formidable as under ordinary conditions, are far more difficult to solve because of the greater chemical affinity at elevated temperatures or disturbing the chemical equilibrium, due to operating difficulties. Only under ideal conditions can problems of oxidation be considered apart from the accelerating effects of other elements than oxygen. The presence of other gases or compounds increases the rate of oxidation, depending upon what metals or conditions are involved.

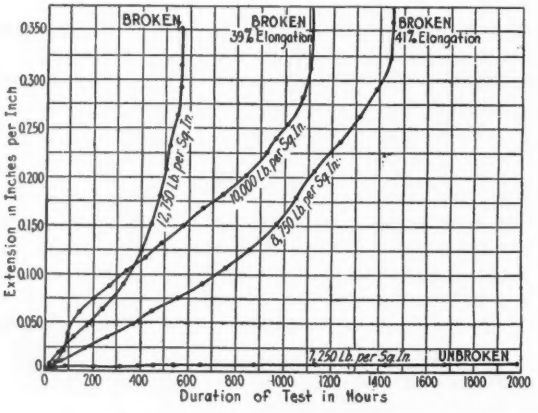


FIG. 3. CREEP TESTS ON WROUGHT CHROME-NICKEL STEEL AT CONSTANT TEMPERATURE (1000 DEG. F.) AND CONSTANT LOAD

(C, 0.30; Cr, 0.49; Ni, 1.33. Quenched from 1525 deg. F. and drawn back at 1100 deg. F.)

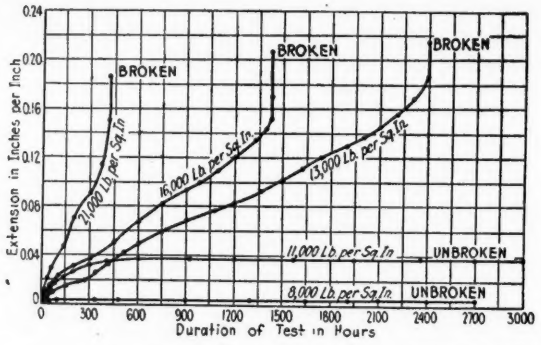


FIG. 4. CREEP TESTS ON CAST CHROME-NICKEL STEEL AT CONSTANT TEMPERATURE (1000 DEG. F.) AND CONSTANT LOAD

(C, 0.31; Si, 0.36; Mm, 0.76; Cr, 0.78; Ni, 1.95. Heat treatment consisted of normalizing to 1725 deg. F. and drawing at 1100 deg. F.)

Therefore, on account of the field being so broad and because of other difficulties, the work of investigators should be that of narrowing down the field of alloys and indicating the trend of progress.

Thermal Expansion

Thermal expansion is one of the most important points that has a direct bearing on design of equipment for safe operation at high temperatures, because it is a well known physical law that when heat is supplied to a body, expansion takes place in all directions and when heat is abstracted, contraction takes place. Most failures taking place at high temperatures, no doubt, are caused by the use of a combination of metals that are entirely unsuited for the work, or from the lack of knowledge on the part of the designer of certain stresses, not readily calculated due to the non-uniformity of temperature distribution. It is no easy matter to avoid deformation caused by temperature stresses which are primarily due to operation or to lack of knowledge in design, so that certain destructive conditions must be accepted in all high temperature work.

Wear and Abrasion

Despite the difference in effect observed by different investigators with various test methods, there are a number of general conclusions which may be drawn from these studies of erosion and wear. Figure 1 is a summary of certain tests upon various metals. As shown in this illustration, hardness appreciably improves performance but hardness itself is no certain criterion of the erosion resistance of various metals as this depends to a great extent upon the structural composition and extremely hard metal is unsuitable to resist

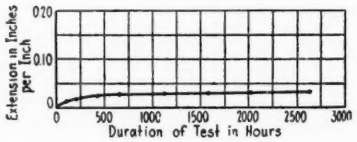
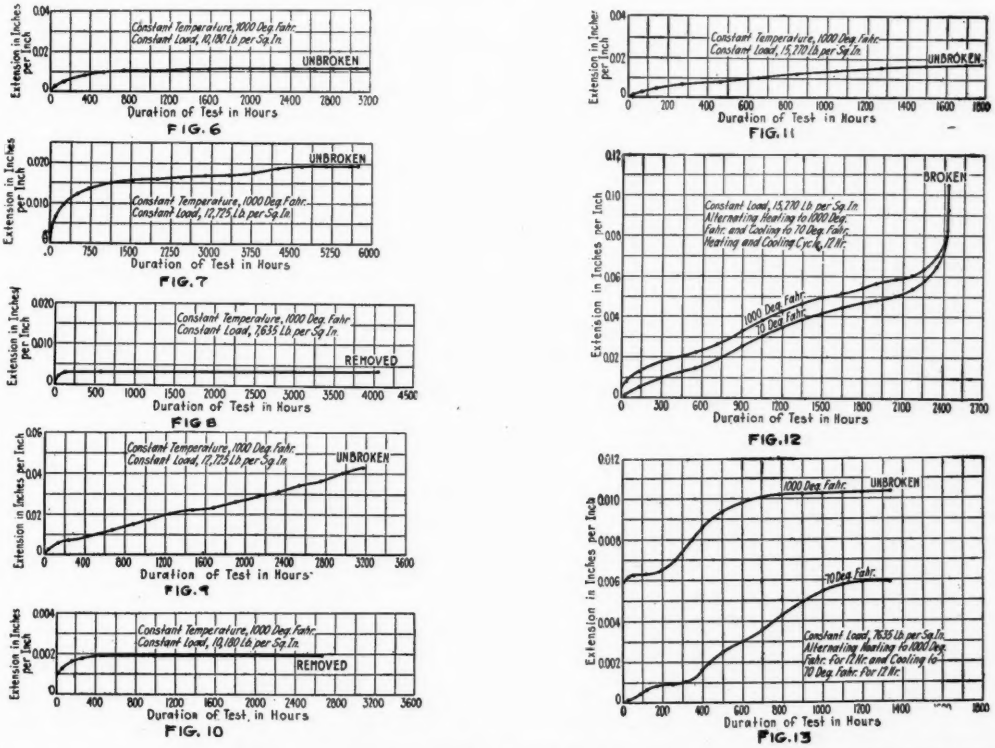


FIG. 5. CREEP TESTS ON WROUGHT CHROME-TUNGSTEN STEEL AT CONSTANT TEMPERATURE (1000 DEG. F.) AND CONSTANT LOAD (10,180 LB. PER SQ. IN.).

(C, 0.34; Mm, 0.75; Cr, 0.69; W, 0.73. Heat treatment consisted of quenching from 1575 deg. F., and drawing back at 1250 deg. F.)

shock on account of its brittleness. Hardened steels that have been tempered, while not so resistant, are far superior for severe service conditions on account of their toughness, and this toughness certainly is a factor that tends to resist erosion and wear.

by various alloy steels and in the accompanying charts are shown data on certain alloys that the author considers of value and safe for operation at 1000 deg. F.—always, of course, depending on the critical stress used in designs.


Extension in Inches per Inch
Duration of Test in Hours
Constant Temperature, 1000 Deg. Fahr.
Constant Load, 10,180 Lb. per Sq. In.
UNBROKEN
FIG. 6
Constant Load, 17,775 Lb. per Sq. In.
FIG. 7
Constant Load, 7635 Lb. per Sq. In.
REMOVED
FIG. 8
Constant Load, 17,775 Lb. per Sq. In.
FIG. 9
FIG. 10
Constant Load, 15,270 Lb. per Sq. In.
FIG. 11
BROKEN
Alternating Heating to 1000 Deg. Fahr. and Cooling to 70 Deg. Fahr. Heating and Cooling Cycle, 12 Hr.
1000 Deg. Fahr.
70 Deg. Fahr.
FIG. 12
Constant Load, 7635 Lb. per Sq. In. Alternating Heating to 1000 Deg. Fahr. for 12 Hr. and Cooling to 70 Deg. Fahr. for 12 Hr.
FIG. 13

FIGS. 6—13. CHARTS SHOWING VARIOUS PROPERTIES OF VARIOUS METALS AT HIGH TEMPERATURES

Figs 6 and 7. Creep tests on wrought Enduro metal. (C, 0.09; Cr, 16.60.)
Figs. 8 and 9. Creep tests on wrought Davis metal. (Cu, 67.25; Mm, 2.10; Ni, 28.30; Fe, 2.25.)
Figs. 10 and 11. Creep tests on low carbon stainless iron. (C, 0.09; Cr, 12.89. Heat treatment consisted of quenching from 1750 deg. F. and drawing at 1100 deg. F.)
Figs. 12 and 13. Special alternating heating and cooling creep tests on cast chrome-nickel steel. (Analysis and treatment same as given in Fig. 4.)

Resistance to erosion does not, in general, increase directly with strength or hardness. Both hardness and toughness are important factors in determining the wearing qualities of a metal because hardness increases resistance to penetration, scratching and displacement of the metal while toughness makes it difficult to tear off small particles of metal, which particles, when torn off by rubbing or sliding action, constitute an abrasive of considerable effectiveness. Therefore, a metal having a certain amount of hardness combined with good impact value, denoting toughness is better suited to resist erosion and wear than one possessing only great hardness.

It has been found by experiment and also practice that when similar metals of the same hardness are rubbed together, they will not slide under pressure without "seizing" or "galling," especially at high temperatures. This condition probably accounts for the fact that when stainless disks and seats of the same hardness have been used in valves, the faces of the disks have been scored or roughened and in a number of cases severe "galling" has taken place.

Considerable information has been published in the last few years with regard to special qualities possessed

Manufacturers Announce Pipe Fittings Made to New Tentative Standard

ATTENTION OF our readers is called to the fact that manufacturers of valves and fittings are now producing steel pipe flanges and flanged fittings in accordance with the new tentative American Standard, developed under the procedure of the American Engineering Standards Committee. One important feature of the new standard is that certain sizes of the new fittings for certain pressures cannot be bolted to old flange drillings, because of difference in number of bolt holes.

Thus, in ordering new fittings, the engineer must know exactly what to specify in the various sizes, in order to avoid delays, confusion and unnecessary correspondence.

It will be well, therefore, to secure from the various manufacturers at once the bulletins and tables they have issued showing the changes in details of their products. Engineers interested in the details of the standard itself can secure copies of it in pamphlet form from the American Society of Mechanical Engineers, 29 West 39th St., New York City.

Emergency Repairs to Diesel Crankshaft Web

CRANKSHAFT WEBS ON TWO DIESEL ENGINES REPAIRED BY SHRINKING A STEEL BAND AROUND THE WEB. BY J. J. McDOUGALL

CRANKSHAFT REPAIRS on Diesel engines are always a matter of serious concern due to the direct expense of the repairs and the loss of time and production while the engine is out of service. Some time ago when checking up the crankshaft alinement, cracks were found in the crank web of the built-up shaft of two engines, as shown in Fig. 3. Since the cost of a new section of crankshaft for the large Diesel engine was considerable and, in addition, meant a delay of several months, it was decided to shrink a steel band around the web.

First the web, which had never been machined, was trued up to a smooth finish on each end, by using an electric grinder swinging around the shaft fixed between the centers of the journals. After the webs were true, a template was made of wooden sections to fit the outside of the web. From the wooden template, a sheet iron template was then made to fit the inside of the wooden one, the sheet iron template being trimmed off to agree with the shrinkage fit.

For the large engine, a four-cylinder, two-cycle, 3100-i.hp. unit, the band was made from a mild steel billet 12 ft. long and 5 by 10 in. cross section, weighing a little over one ton. It was forged into an oval or egg-shaped band by the blacksmith, and the joint arc welded. It was then measured and machined to proper dimensions with allowance for shrinking in order to render sufficient stress to close the crack, hold the parts in place and take up the working strains of this section of the shaft.

In Fig. 3, A and B are actual dimensions of the crankshaft, A being 31.625 in. and B being 22.75 in., an initial stress of 10,000 lb. per sq. in. was assumed, giving an elongation coefficient of 10,000 ÷ 29,000,000, or 0.00034. The face dimensions of the band (A — 0.030) and (B — 0.013) were obtained by multiplying the dimensions A and B by the elongation coefficient and adding an allowance for roughness and, in the case of A, for the crack in the crank web. Mathematically this can be expressed as $31.625 \times 0.00034 = 0.011$ and $0.011 + 0.005$ (for roughness) $+ 0.0014$ (for crack), gives a total allowance of 0.030 in. In the case of B the allowance is $22.75 \times 0.00034 = 0.008$ and $0.008 + 0.005$ (for roughness) gives a total allowance of 0.13 in. No allowance need be made for the crack in this case.

Allowing 30,000 lb. per sq. in. and subtracting 10,000 lb. per sq. in. for shrinkage limit, gives 20,000 per sq. in. allowable working tension. Taking 60 per cent of the available working tension of 20,000 lb. per sq. in. allows 12,000 lb. per sq. in. safe working stress. The net section is $5.75 \times 3.875 = 22$ sq. in., giving a total of $22 \times 12{,}000$, or 265,000 lb. total working stress. The lever arm from the center of gravity of the band section end is 13.25 in., so that the allowable moment on the crankshaft would be $265{,}000 \times 13.25$ or 3,520,000 lb. At half stroke, $352{,}000 \div 13 = 270{,}000$ lb. allowable as cylinder load. Two cranks, therefore, will give a total of 540,000 lb. thrust, or with a piston area of 406.5 sq. in., the equivalent pressure in the cylinder that the band would safely resist at half stroke would be $540{,}000 \div 406.5$, or 1325 lb. per sq. in.

As the shaft was not removed from the engine, it was necessary to pass the band over another web of exactly the same size as the one to be repaired in order to place it on the proper crank web. While the machine shop was making the band, the repair crew disconnected the shaft section and blocked it up high enough to enable the band to be slipped over the web, bolted an I-beam to the bottom of the cylinder and installed a trolley with a 1.5-t. chain block, as shown in Fig. 2.

On receiving the web, it was heated red hot in a nearby temporary furnace and, by means of the crane and two chain blocks, was slipped in position on the shaft and allowed to cool. When the shaft was dropped into place, two pins, indicated in Fig. 3, were put in and welded to the band in order to prevent the web from moving sideways in case it failed to hold the load.

While the life of a repair job of this nature is uncertain, the work was completed in good time, the engine placed in service with a comparatvely small cost and loss of time.

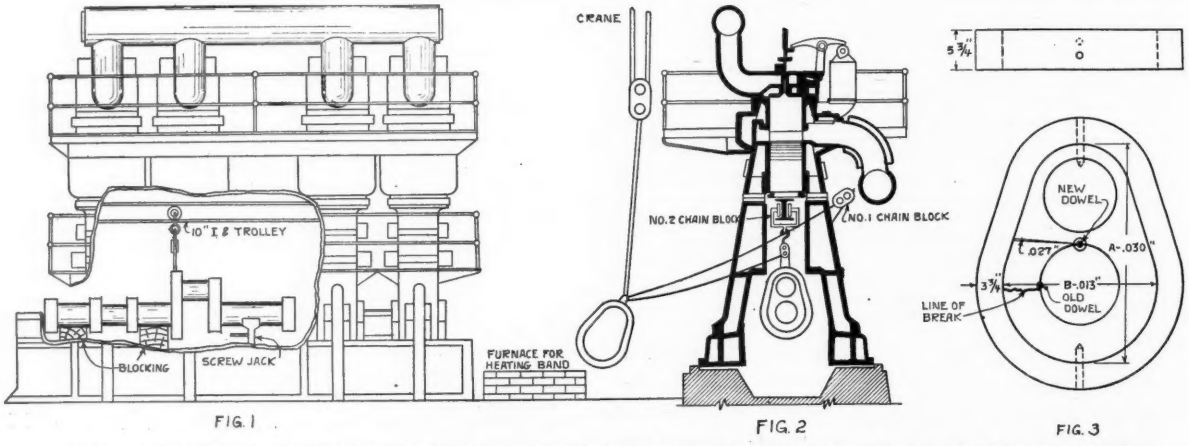
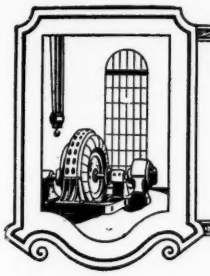
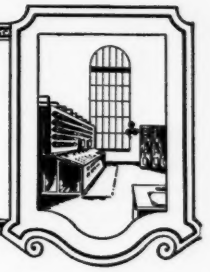


FIG. 1. LONGITUDINAL SECTION OF THE ENGINE SHOWING THE METHOD OF BLOCKING UP THE SHAFT
FIG. 2. CROSS SECTION OF THE ENGINE SHOWING THE METHOD OF LOCATING THE I-BEAM AND CHAIN BLOCK
FIG. 3. DETAILS OF STEEL BAND



ELECTRICAL MACHINERY FOR LIGHT AND POWER



Some Notes on Converter Excitation

COMPARISON WITH INDUCTION MOTOR; STARTING FROM THE A.C. SIDE; CORRECTING POLARITY; SPARKING AT STARTING PERIOD. BY W. F. SUTHERLAND

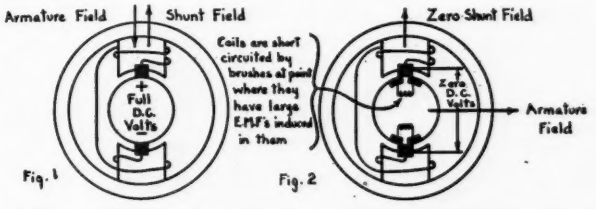
STARTING LIKE an induction motor, running like a synchronous motor and delivering direct current, the rotary converter is a versatile sort of a machine. Combining as it does many of the characteristics of all three machines, many interesting peculiarities come to light, especially in problems involving excitation.

Like the induction motor, the converter possesses a polyphase winding although on the armature or rotor instead of on the stator as is usually the case. Like the induction motor also, it possesses a squirrel cage winding although on the pole tips. Contrary to the induction motor, however, the converter field structure is of the salient pole type.

When a converter armature has starting voltage applied to it, a rotating field of magnetic flux is created which, reacting against the squirrel cage winding on the field poles, causes the armature to turn over and come up to speed. The armature rotates in the opposite direction to its own rotating field and, in consequence, as its own speed increases, the speed of rotation of the magnetic field, with respect to the stationary portions of the converter, becomes slower and slower until at synchronism it becomes stationary, its magnetic poles alining themselves with the salient poles of the converter stator. In this the converter differs from the induction motor. In the latter, assuming for the moment that the windings are on the rotor with the squirrel cage on the stator, the rotating field would slowly drift around the axis of the machine at a speed equal to the slip frequency. In the converter, however, the rotating field as synchronism is approached tends to lock into the polar projections as they are passed on account of the much lower reluctance there than in the interpolar spaces. This pull-in effect increases as the speed of the rotating field decreases until at almost synchronous speed, the effect is strong enough for synchronous running to be effected.

This armature field plays a most important part in the counter e.m.f. produced in the armature conductors. It produces a sort of transformer action since it continuously cuts the armature conductors both at standstill and full speed. In the first case the armature conductors are stationary and the field rotates, while in the latter the reverse is the case. At both standstill and full speed and all speeds in between, a counter e.m.f. is generated which effectively opposes the applied e.m.f. with these differences.

At standstill, the reluctance of the magnetic circuit to the rotating field is a variable quantity due to the salient pole construction and is considerably greater than at synchronism. Also at speeds other than synchronism the squirrel cage windings carry current. The



FIGS. 1 AND 2. FLUX RELATIONS IN ROTARY CONVERTER

Fig. 1. Flux relations at beginning of cycle of pole slipping. The armature and shunt fields are in opposition and the resultant field weak. Fig. 2. Flux relations at intermediate stage of pole slipping. Armature field is intermediate between pole shoes and in wrong position for production of d.c. voltage.

combination of course results in a large current;—a greater exciting current and a power current which goes to accelerate the revolving mass.

At synchronism the squirrel cage windings are idle and sufficient energy flow occurs to compensate for losses only, while the exciting current flowing as in all transformer actions is of sufficient amount to overcome the reluctance of the magnetic circuit and obtain the proper amount of flux to establish the correct counter e.m.f.

This exciting current, by the way, is much larger than that found in transformers, or even induction motors. In the induction motor the exciting current is designedly kept low, the air gap and other reluctance being kept down to a small value. In the converter other considerations necessitate a larger air gap and the salient pole construction also has the effect of increasing the reluctance.

For this reason, a converter running light may, with no d.c. excitation draw full load current (largely reactive) from the lines.

At synchronism, as we have seen, the armature field is fixed in space and, in common with all rotating fields, may be of constant amplitude. Also it is alined with the polar projections and circulates through the field structure. It thus has all the characteristics of a field

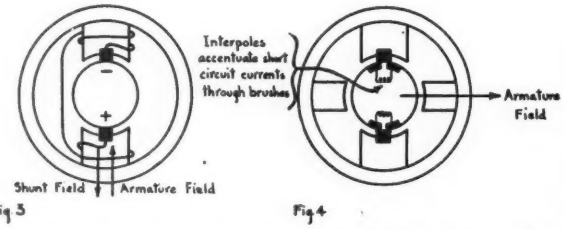
produced by direct current and may thus be replaced by such a field, giving us d.c. field excitation.

If so replaced, the direct current excitation in whole or in part eliminates the necessity for a.c. magnetizing energy and thus we may have a converter drawing lagging current from the lines, running at unity power factor or even supplying leading current to the a.c. circuit if over excited.

Direct current excitation is not required, of course, for the production of d.c. voltage at the commutator. The action can be considered as that of a rectifying commutator or the fixed field can be considered as giving a true direct current generator action. Although this is true, it is not practicable, to say the least, to run a converter without excitation under load, for a number of reasons, principally because of the excessive lagging current drawn from the a.c. mains and the excessive heating thus produced.

Starting from A.C. Side

Rotary converters when started from the alternating current side are variable as to the resulting direct current polarity. With no d.c. excitation, it is easily seen



FIGS. 3 AND 4. MORE FLUX RELATIONS IN CONVERTER

Fig. 3. Flux relations at a time when the armature has slipped a complete pole piece. Flux relations are such that fields still buck. Fig. 4. Showing effect of interpoles in increasing armature field flux during pole slipping or running out of synchronism.

that the armature is apt to lock in with a north pole on any salient pole of the field and in view of this is just as likely to come up positive or negative on any set of brushes. With the field in circuit the same is true since the voltage across the d.c. brushes and thus also impressed across the field windings is alternating in character during the starting period, first at the frequency of the supply circuit and slowing down until at synchronism it reaches zero frequency and becomes a direct current. Such being the case, self field excitation has no effect on the likelihood of obtaining correct polarity. Separate excitation of the fields from some d.c. source does not definitely fix polarity since for instance a north field pole would have a much greater attraction for a south pole of the armature field than for a north pole, thus defining the position at which final locking into synchronism takes place.

Correction of Polarity

For the correction of polarity, fields are usually fitted with double throw switches so that the shunt field windings can be reversed with respect to the brushes. Assuming that a machine has come up in the wrong direction, the field switch is reversed and the d.c. excitation then begins to buck the armature field, lessening the hold-in torque and eventually setting the armature free and dropping it out of synchronism. As the armature slips back a pole pitch the d.c. voltage dies down to zero, the brushes being in the wrong position for an instant for packing up the rectified current, Fig. 2; at this instant, the operator again reverses his field switch. The probability is that the converter will lock in on the next pole in order and will thus come up with correct polarity.

Occasionally, however, the armature field is too strong or the shunt field too weak thus to throw the machine out of synchronism and effect this pole slipping. In such a case, the high tension breaker has to be opened for an instant and then closed, with the resulting chance of catching correct polarity when synchronism is again reached.

This question of polarity and pole slipping is productive of rather interesting problems. For instance, while it may not be evident at first glance, the shunt fields of a rotary converter can be connected up in only one way for proper running. Consider a converter up to speed and with the field switch open, the fields however being so connected that when the field switch is closed in the running position the resulting direction of flux is such as to oppose the armature flux. When the field switch is closed under these conditions, the machine slips a pole as described above and tends to build up with opposite polarity; however, since the polarity at the brushes is reversed, the field current direction will now be reversed also and the field excitation, although of opposite polarity to that before obtaining, will still buck the armature field. This results in a further slipping and a slow rotation of the armature field ensues, the machine running out of synchronism indefinitely. The sequence of events is shown in Figs. 1 to 3.

A permanent magnet voltmeter connected across the brushes would show an alternating current of slow frequency.

Rotary converters with a bucking shunt field show severe sparking at the d.c. brushes and excessive heating of the armature coils. This can best be explained by considering the action as being similar to that obtaining in a direct current generator, in which the brushes, instead of being fixed in the best position for commutation, were slowly rotated around the commutator from the best position for commutation through all intermediate positions to the worst. Obviously perfect commutation is impossible.

Sparking During Starting Period

A similar analysis explains sparking during the starting period since here also the armature field is not stationary with respect to the brushes but rotates rapidly at first and more slowly as speed increases. Fortunately in the rotary converter when the armature field is in its worst position with respect to commutation, it is also weakest since it lies in an inter-polar space. This is not the case where interpoles are provided, Fig. 4, the field being strong in view of the low reluctance of the path through the interpoles and sparking in consequence is quite pronounced. Brush lifting devices are accordingly necessary, a pilot brush only being left down.

It is more or less a matter of indifference as to whether the shunt fields be excited during the starting period or not. If the shunt field be left open, a smaller starting load is imposed on the lines since no losses occur in it, while, on the other hand, voltage stresses are increased. The rapidly rotating armature field cuts the field windings and at the initial instant would give rise to an alternating voltage equal to the impressed voltage times the turns ratio, were it not for the leakage reactance characteristics of the machine and the shielding effect of the damper windings. These latter act as a short-circuited secondary interposed in front of the field windings. Such induced voltages rarely rise above 20 per cent of the turns ratio value. Fields, however, should be provided with break-up switches or field discharge resistances if open-circuit starting is practiced.

Throughout all of the above the no-load condition has been assumed, load current flowing through the machine introduces another set of conditions entirely. The armature field spoken of above should not be confused with the armature reaction field, on load, which is altogether a different thing.

Selection of Most Suitable D. C. Generators

A Discussion of the Characteristics and Application of All Types of Direct Current Generators

BECAUSE OF THE different electrical characteristics of direct current generators a machine suited to one application may be entirely unsuited for another. The selection of the proper type of generator for a particular application will greatly increase the satisfaction obtained by the user. In the March, 1928, issue of the Electric Journal, Scott Hancock, motor engineer of the Westinghouse Electric & Manufacturing Company, discusses the selection of the most desirable type of d.c. generator with unusual clearness and it is hoped that this abstract of Mr. Hancock's article will enable those using d.c. equipment to select this equipment more intelligently.

The chief differences in electrical characteristics between different varieties of direct current generators are found in their volt-ampere curves. Since these curves are determined chiefly by the field winding used, machines having the various types of characteristics are usually known by their field winding, as shunt, compound, differential compound, separately excited, etc.

In Fig. 1 are shown the volt-ampere curves of a 125-v. shunt generator, the parts that are ordinarily used in operation being shown as solid lines. Ordinary shunt generators cannot be operated satisfactorily below about ⅔ of the rated voltage. When specially ordered, it is possible to build a shunt generator which will operate down to about ⅓ normal voltage without encountering trouble with stability.

Shunt Generators as Exciters

Shunt machines are especially desirable as exciters for use with vibrating type regulators because all the main field windings are directly under the regulator control. If compound-wound exciters are used, the regulator has control of only one part of the field; that is, it controls the shunt, but not the series field. Shunt machines, therefore, are more responsive to regulator control. For the charging of single lead batteries, the ordinary shunt generator is also desirable, because in this application it is essential that the voltage drops off slightly with increase of load. Since the shunt generator has approximately this characteristic, it is often used for this purpose.

Sometimes a generator is connected to a battery, and is continuously charging at a very low rate. This is called trickle charging. There are two reasons why generators used for this work should be shunt wound. The first is that if the generator voltage for any reason should drop below the battery voltage and the battery feed current into the generator driving it as a motor, in a compound generator the series field would become

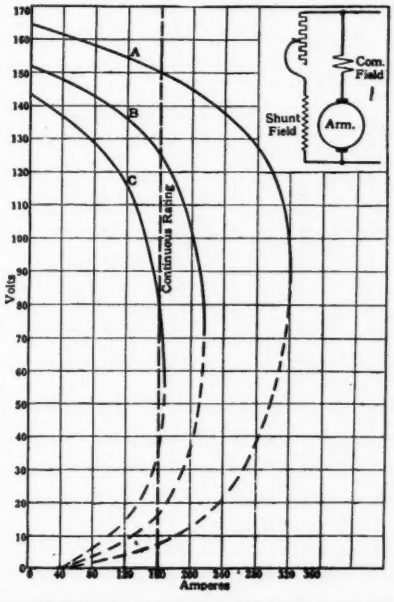


FIG. 1. CONNECTIONS AND REGULATION CURVES OF A SHUNT-WOUND GENERATOR

Curves A, B and C were obtained by varying the field rheostat.

differential. The second reason is that, when the switches operate, they take a considerable load and cause the battery voltage to drop. If the generator is compound, it will try to supply power to keep the voltage from dropping and will have to be made large enough to carry the heavy load.

Shunt wound generators are also useful as exciters to operate over a wide voltage range when under manual control. If machines intended for this purpose are made with any appreciable degree of compounding at the maximum voltage, they will be greatly over compounded at the minimum voltage and it will be impossible to control them satisfactorily by means of the exciter field rheostat.

For parallel operation, the shunt wound generator always lends itself well because of the simple connec-

tions. Compound machines can, of course, be operated satisfactorily in parallel, but the connections and adjustments are not quite as simple as for shunt machines.

Compound Generators Most Suitable for General Power Service

The connections and regulation curves of a compound wound generator are shown in Fig. 2. The series field may oppose or assist the shunt field. When it assists the shunt field, the machine is known as additively compound or, more often, the word additive is omitted and the machine is called simply a compound

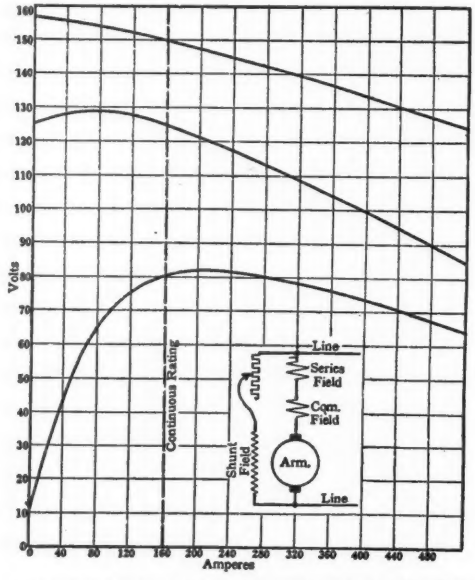


FIG. 2. CONNECTIONS AND REGULATION CURVES OF A COMPOUND-WOUND GENERATOR

The regulation curves were taken with the series field aiding the shunt field.

machine, while the generator in which the series opposes the shunt field is known as a differentially compound machine. The curves shown in Fig. 2 are those of a typical additively compound machine. This type of machine should not be operated at a voltage much lower than rated. Its characteristics change with reduction of voltage much more than those of the shunt machine, so it is more imperative that the compound generator be operated reasonably near the rated voltage than for the shunt generator.

Since by the use of a series winding a generator can be made to have approximately the same voltage regardless of load and since it is desired to keep a constant voltage on lights or motors, the compound machine is most often used for application where there is a lighting or general power load. This is one of the most usual applications for the direct current generator. For this application, generators are sometimes made so that the voltage rises slightly as the load is applied. This is done for two reasons. First, it tends to compensate for the I. R. drop of the line and second, as the load is usually between a quarter load and full load, the voltage between these two loads remains more nearly constant if the no load voltage is permitted to be below that at full load.

Arc Welding

In electric arc welding service, several welders may derive their power from a common generator. The chief essential is that the voltage shall stay approximately constant regardless of the load and, for this purpose, the generator should be a flat compounded machine over the operating range.

Exciters for Use with Rheostatic Regulators

When an exciter is used with a rheostatic regulator, the rheostat in the field of the synchronous machine and not the field on the exciter is under the control of the regulator. The regulator uses the exciter voltage on certain of its coils. If the exciter voltage varies excessively as the regulator changes the load on the exciter by changing the resistance in series with the field of the

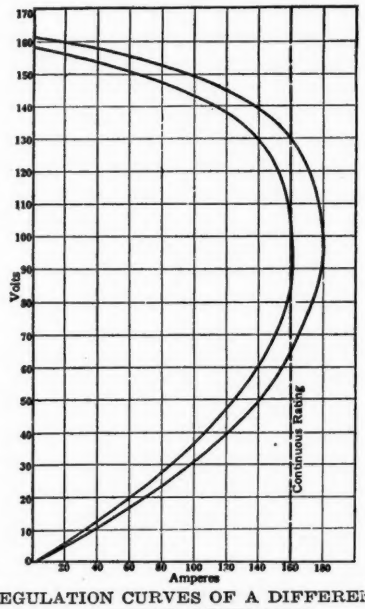


FIG. 3. REGULATION CURVES OF A DIFFERENTIAL COMPOUND GENERATOR

synchronous machine, then the regulator coils energized by the exciter voltage may at times be overworked and be in danger of burning out. To avoid this, it is desirable that the voltage change due to change of load be not very great and while the desired characteristics can sometimes be obtained from shunt generators, their droop is usually too great so under compound generators are used.

If the exciter is not to be used with a vibrating type regulator and if all the control of the synchronous machine field curve is obtained by an adjustment of the rheostat in the synchronous machine field, then a compound exciter presents a slight advantage over a shunt exciter because a rheostat of lower resistance can be used in the synchronous machine field.

In the first part of this article the advantage of the shunt wound generator in charging single lead storage batteries was pointed out.

In the multiple charging of lead storage batteries, however, the compound wound generator must be used. This is due to the fact that a number of different batteries are usually connected to such a generator, all in

different stages of charge and discharge and, to obtain the desired voltage across the battery, it is necessary to use a resistance in series with each battery. It is obvious that in this case the generator voltage must not change appreciably as different batteries are put on the line and the generator must be made as flat compound as possible.

Differentially Compound Generators

The differentially compound generator is the same as an additively compound one except that the series

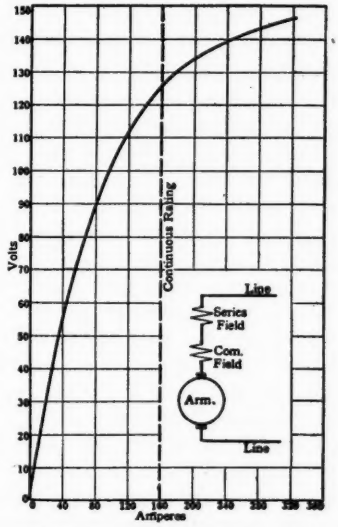


FIG. 4. CONNECTIONS AND REGULATION CURVE OF A SERIES-WOUND GENERATOR

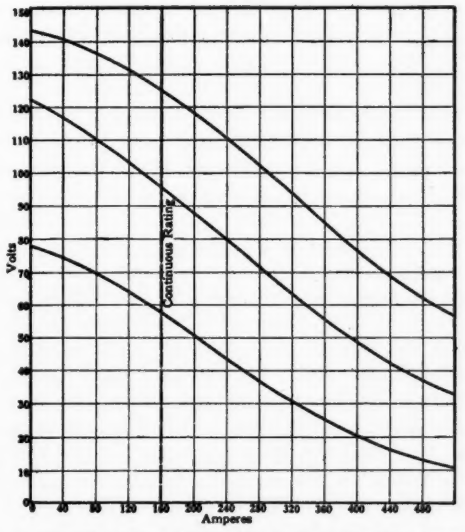


FIG. 5. REGULATION CURVES OF A SEPARATELY-EXCITED SHUNT GENERATOR

field strength opposes that of the shunt field instead of assisting it. The two most usual applications for such generators are in the charging of single Edison batteries and for series arc motion picture sets. In the case of Edison batteries, it is desirable to have approximately constant current from the beginning to the end of the charge. As with the lead cells, the voltage across the battery increases as the charge progresses. It may be seen by referring to the curves of Fig. 3 that for a comparatively wide range in voltage the current is practically constant.

In the series generators no shunt coils are used. The connections and a typical curve are shown in Fig. 4. There is only one application of a series generator that is at all usual and that is for use as a booster generator. Frequently it is desired to compensate for the resistance drop of a line carrying direct current, and it is desired to have this compensation take place at a considerable distance from the generator. In some way the voltage at some point on the line must be increased an amount equivalent to the voltage drop from the generator to that point. Since this drop is practically proportional to the load current, the voltage added should be directly proportional to the load current.

TABLE GIVING APPLICATIONS FOR VARIOUS TYPES OF D.C. GENERATORS

APPLICATION	TYPE
Arc welding, multiple operator	Compound
Arc welding, single operator	Separately excited, differentially compound
Battery charging for Edison batteries, single	Differentially compound
Battery charging of lead batteries, Multiple	Compound
Battery charging of lead batteries, Single	Shunt
Battery charging, trickle, of central station lead batteries	Shunt
Boosters	Series
Exciters, constant voltage under manual control	Compound
Exciters used with rheostatic regulators	Compound
Exciters used with vibrating type regulators	Shunt
Exciters, wide voltage range, manual control	Shunt
Extremely high or low voltage	Separately excited
Motion picture, constant potential	Compound
Motion picture, series arc	Differentially compound
Power and lighting	Compound
Variable voltage	Separately excited
Variable voltage, electric shovels	Separately excited, self excited differentially compound

The series generator, unless overloaded, gives such a characteristic as is shown by the curves of Fig. 4.

Separately Excited Generators

Direct current generators are sometimes excited from sources of power other than their own armatures. Such generators are said to be separately excited. The use of machines of this type is limited to certain special applications and their use in the power plant is extremely rare. In the paper industry, they are often used as generators for variable voltage sets for single motor paper machines. They are also used when the voltage of the generator is not suitable for use for excitation. For example, radio generators have rated voltages of 1500 v. or more. It is not feasible to make shunt fields and rheostats for such voltages, particularly on small machines, so such generators are made separately excited.

In concluding this article, attention is directed to the table shown herewith. To obtain the most desirable results for various applications of direct current generators, generators of the type indicated in this table should be used.

Muscle Shoals Bill May Establish Precedent

ACTION OF UNITED STATES SENATE IN PLACING GOVERNMENT IN POWER BUSINESS IN ALABAMA LIKELY TO BE FOLLOWED AT BOULDER DAM, ON THE ST. LAWRENCE AND ELSEWHERE. BY WINGROVE BATHON*

AFTER A DEBATE lasting 7 yr., the United States Senate has finally passed the so-called Government ownership and operation measure for Muscle Shoals hydroelectric and steam plants, the measure that bears the name of Senator Norris. A precedent of the utmost importance to the electric power industry has thereby been established and it may have far-reaching consequences. It is true that when the bill reached the House Committee on Military Affairs, it received scant consideration, having been rejected by a vote of 16 to 4; but the proponents of the Norris bill in the House of Representatives are already saying that when the Military Committee reports out a bill, of any kind, the move will be made to substitute the Norris measure for the new one offered. In any case, these proponents claim, it will be found in the end that the principles enunciated in the Norris bill will be written into any measure passed by the House. Indeed, as this is written, a new measure, known as the McSwain bill, which contains many of the principles of the Norris measure, is already under consideration in the House.

Government ownership enthusiasts hail the passage of the Norris bill in the Senate with eagerness. One Senator remarked that it blazed the trail across the map of the United States for nationalizing the power industry; other enthusiasts were quick to say that if the Senate could approve of the Norris Government operation measure for Muscle Shoals, more than likely the Senate would approve Senator Johnson's bill concerning the proposed Boulder Dam projects. In fact, shortly after the Senate acted on the Muscle Shoals measure, both the House and Senate Committee on Irrigation and Reclamation favorably reported the Boulder Dam project bill, containing features similar to those of the Norris Muscle Shoals bill. The Boulder Dam bill will be dealt with a little farther on in this article.

Furthermore, Government electric power ownership and operation advocates saw in the action of the Senate on Muscle Shoals the opportunity to urge the "pumping plan" in the Columbia Basin irrigation project, as well as similar Government participation in the proposed power projects along the St. Lawrence River. This river was alluded to by Major Glen E. Edgerton of the Federal Power Commission in his address at the Midwest Power Conference[1] in Chicago recently, as the best power river remaining undeveloped in the United States. Applications for licenses along the St. Lawrence, totaling an initial installed capacity of 5,000,000 hp., are now being held up by the Federal Power Commission, pending an international agreement by treaty. But some day that treaty will be made and there will be bills to develop the St. Lawrence projects, probably with Government money. A description of these pending St. Lawrence projects will also be given farther along in this article.

The precedent involved in the Norris bill for Muscle Shoals is that it sets up Government ownership and operation of power plants as a Government policy, after 7 yr. of examination by committees and endless debate on the floor of the Senate, at the end of which that proposition was adopted by the Senate during straight-out fights to lease the power plants at Muscle Shoals to private bidders.

The Senate was apparently convinced that Muscle Shoals offered an opportunity to ascertain whether it would be possible to produce, sell and distribute electric power cheaper by the Government than by private industry. This decision was influenced by the frequent charge that rates made by the power and light companies are excessive as compared with the cost of service in municipally-owned plants, such as those at Springfield, Ill., Tacoma, Wash., the system of the Ontario Hydroelectric Commission and others. States, counties, municipalities and non-profit organizations are given in the Norris bill a preferential right to use any power that is not needed for the manufacture of fertilizer. The Secretary of War is authorized to build transmission lines to take down the power from Muscle Shoals and distribute it, in case he ever thinks it necessary. Notwithstanding the fact that there are in existence in the Southeastern states, within the sphere of influence of Muscle Shoals, state public service commissions which are charged with the duty of regulating service and rates of power and light, under the Norris bill whatever power is left after fertilizer manufacture, and after giving preference to states, counties, municipalities and non-profit organizations, must be subject to regulation by the Federal Power Commission, ignoring the rights of the states and the duties of the state commissions already in existence to do such regulation.

CONFLICT OF RATE-MAKING AUTHORITIES

The practical result is that the Secretary of War is directed to allocate power between various states, counties and municipalities; the further practical result is that both the Secretary of War and the Federal Power Commission become rate-making authorities in conflict with the state commissions. Authorization is given in the bill to install the units not yet placed in the hydroelectric power house at the Wilson Dam at Muscle Shoals, and authorization is given to bring up the capacity of the reserve steam plant at the Wilson Dam from its present 80,000-hp. capacity to its proposed 120,000-hp. capacity. These authorizations, with the preferences specified for states, counties, municipalities, etc., with the authorization to the Secretary of War to build transmission lines in any direction he sees fit, and with regulation provided by the Federal Power Commission, with an appropriation of $10,000,000 to begin with and involving a program which will involve annually additional millions of dollars of appropriations,

*Washington Correspondent of Power Plant Engineering.
[1] Power Plant Engineering, April 1, 1928, page 425.

puts the United States Government into the steam as well as the hydro-electric power business, in competition with private industry in the surrounding states.

It is a fact, also, that under the Norris bill the Federal Government is to engage in the business of manufacturing fertilizer ingredients. It is true that the intention, when this bill came out of Committee, was that the Government should so engage in the fertilizer and chemical industries only so far as large-scale experimentation is concerned; but during the debate on the floor, Senator Norris found that he could assist the passage of his bill by consenting to an amendment which requires the Secretary of Agriculture to operate Nitrate Plant No. 2. That plant has a capacity of 40,000 t. of fixed nitrogen per annum, and notwithstanding the fact that Senator Norris, more than any other man in the United States, has proved again and again that the process of extracting nitrogen from the air at Nitrate Plant No. 2, using the cyanamid process, is out-worn and is being dropped all over the world, the politicians in the Senate who have so frequently promised the farmer cheaper fertilizers by operating Nitrate Plant No. 2 gained the ascendency and Senator Norris accepted the amendment in order to assure the passage of his bill. The bill passed the Senate by a vote of 48 to 25, almost 2 to 1.

Further Developments on Tennessee River

Consideration has been given for some time, in connection with Muscle Shoals legislation, to the application of the East Tennessee Development Co. to be permitted to develop eleven dam-sites on the Powell, Clinch and upper Tennessee Rivers. These applications before the Federal Power Commission have been held up and will be, pending settlement of the Muscle Shoals controversy. That is because one of those eleven dam-sites is the one known as Cove Creek. That is a storage reservoir dam, primarily, and it is 400 mi. up the river from Muscle Shoals. The people of East Tennessee are badly in need of additional power facilities. The Railroad and Public Utilities Commission of the State of Tennessee last November undertook to levy a tax of 1 mill per kilowatt-hour upon hydro-electric generation in that state. The writer described the Tennessee situation in connection with the Cove Creek and the ten other dam-sites just alluded to, in connection with these taxes, in Power Plant Engineering for December 1, 1927. The Chancellor of the State has just handed down a decision that this tax cannot be levied. That gave great hope and comfort to the people of East Tennessee. It was for a time thought that there might be final Muscle Shoals legislation at this session of Congress, thus releasing these eleven dam-sites from the grip of the Federal Power Commission, but the Rivers and Harbors Board of the War Department, having made a special survey of the Tennessee River,[2] has just sent to Congress a report showing that the Cove Creek dam and the proposed dam No. 3, the latter to be built just above the Wilson Dam at Muscle Shoals, will cost a good many more millions of dollars than engineers had heretofore estimated. So the question will come up in Washington soon as to whether or not East Tennessee is to have additional hydro-electric power plant facilities or whether East Tennessee will have to rely on steam. The economic and engineering factors are now under consideration by the companies concerned.

But, stimulated by the passage of the Norris Muscle Shoals bill in the Senate, the House of Representatives is now dealing with the McSwain bill which goes much farther than the Norris bill in the Senate, so far as Government ownership and operation features are concerned, because under the McSwain bill it is proposed that the Government shall build the Cove Creek dam and Dam No. 3 at an expenditure of between $75,000,000 and $100,000,000. In other words, the Government ownership and operation precedent in the Norris bill in the Senate has already had its effect upon the authors of the McSwain measure in the House.

Boulder Canyon Project

With regard to the Boulder Canyon project, it is felt that the House and Senate may both take action on the Johnson bill providing for this development, on the strength of the action taken on the Muscle Shoals bill. The House Committee on Irrigation and Reclamation reported the Boulder Canyon bill March 15 and the Senate committee reported it March 21.

The bill states that inasmuch as the Colorado River is an interstate and international stream and that various conflicting uses of its waters are involved, the Government is the proper and logical agency to undertake its development. It also reviews the Colorado River compact and the various phases of the formation of the project.

Briefly, the development is designed to include:

I. A dam 550 ft. high at Boulder or Black Canyon, to impound 26,000,000 acre-ft. of water, at an estimated cost of $41,500,000.

II. Power plants to utilize the power made available by this dam, the construction of these plants to be optional with the Secretary of the Interior. It is estimated that 1,000,000 hp. at a load factor of 55 per cent can be developed here at a cost of $31,500,000.

III. An all-American canal from river to the Imperial Valley and Coachella Valley to cost $31,000,000.

This means an appropriation of $104,000,000 with interest of $21,000,000 on the construction of the works, making $125,000,000 the amount of the total appropriation. The interest item does not, of course, represent an actual appropriation and if the Secretary should elect not to build the power plants, the cost of construction of the works would reduce to $72,500,000 with a corresponding reduction in the interest charges.

The project, as outlined above, and previously described in these columns,[3] is intended to accomplish several purposes. First, it is designed to end the flood menace of the lower valley and guarantee the Imperial Valley a dependable water supply. Second, it is intended, by means of the canal, to replace the present water supply canal to the Imperial Valley, which at present runs 60 mi. through Mexico. Third, it is intended to provide water supply for Pacific coast cities by control of flood waters. Fourth, the sale of power developed will aid in financing the project, the bill states. Fifth, the dam is intended to improve navigation. Sixth, cer-

[2] Power Plant Engineering, April 1, 1928, page 438.

[3] Power Plant Engineering, Feb. 15, 1928, page 257.

tain international complications now existing will be solved by construction of the project.

Several Plans Have Been Advocated for the St. Lawrence

While these Muscle Shoals, Boulder Dam and other power project bills are being discussed and debated in Washington, it will probably be of interest to turn away from the Southeast and far western parts of the United States for a few moments and glance at the proposed 5,000,000 hp. of plants, licenses for which have been applied for before the Federal Power Commission, to be built along the St. Lawrence. All of the schemes provide for 14-ft. navigation and control of the river flow through regulating the level of Lake Ontario. If the Muscle Shoals Government ownership and operation bill should become law or the Boulder Dam Government ownership and operation bill should become law, or both, it is merely a question of time before there will be bills in Congress to nationalize more of the power industry on the Northern borders of the United States.

License applications being held up in connection with the St. Lawrence are as follows: The St. Lawrence Transmission Co. of Potsdam, N. Y., filed an application June 19, 1920, for a preliminary permit for a power project at the Long Sault Rapids, St. Lawrence River, State of New York. The company proposed to construct three dams in the river extending from lock No. 20 of the Cornwall Canal on the Canadian shore to the eastern end of Barnhart Island, from the western end of Barnhart Island to the eastern end of Long Sault Island and from Long Sault Island to the New York shore near the inlet of the Massena power canal; a sluiceway with suitable control gates across Long Sault Island opposite lock No. 21 of the Cornwall Canal; a power canal between Barnhart and Sheek Islands following the river channel and then across the eastern end of Barnhart Island; two or more power houses near the eastern end of Barnhart Island. The elevation of the water surface in the reservoir would be 200 ft. above sea level or higher to conform to plans adopted by the United States and the Canadian governments for canalization of this section of the river. The back water would extend to Ogden Island. The probable installed horsepower would amount to 750,000 and the power capacity was estimated to be 608,000 hp.

The Louisville Power Corp. of Massena, N. Y., on October 5, 1920, submitted a revised application for a preliminary permit for a power project at Cat Island, instead of Croil Island, as stated in its application of July 8, 1920, in the St. Lawrence River, in the State of New York, near the towns of Louisville, Massena and Ogdensburg. The development involves the use of Lake Ontario as storage to the extent of 2 ft. drawdown to provide a minimum regulated flow of about 190,000 c.f.s., and the construction of two power houses and a dam in the river with a spillway capacity of about 450,000 c.f.s. At each end of the dam it is proposed to erect a power house which would contain approximately 36 units with an aggregate installed capacity of 600,000 hp., to operate under a static head varying from 36 to 30 ft. Between the power house on the Canadian side of the International boundary and shore would be a lock for navigation. The estimated power capacity of the project is 547,000 hp. and the total installed capacity, 1,200,000 hp.

The New York and Ontario Power Co. of Waddington, N. Y., filed an application on January 7, 1921, for a license for a power project at Ogden Island (Isle au Rapide Plat) in the Little River which forms the south channel of the St. Lawrence River near the town of Waddington. The applicant proposes to reconstruct its present dam and power plant or build new hydraulic structures in said channel and to place a rock-fill between Ogden and Canada Islands and so obstruct the river as to divert and maintain through its power plant a uniform flow of 30,000 c.f.s. with an average static head of 11.2 ft. The power capacity of the project is estimated at 26,880 hp. and the installed capacity at 30,000 hp.

The New York and Ontario Power Co. of Waddington, N. Y., made application on January 12, 1921, for a preliminary permit for a proposed power project in the St. Lawrence River between the easterly ends of Murphy Island and Lotus Island in the vicinity of Ogdensburg, utilizing the available flow and head in that section of the river. Plans of the development are lacking. The power capacity of the project is estimated to be 395,200 hp. and the installed capacity would total 400,000 hp.

The American Super-Power Corp. of Lewiston, N. Y., filed application on February 5, 1923, for preliminary permits for two water power developments on the St. Lawrence River near the towns of Waddington and Massena, N. Y., which application was amended July 31, 1926, so as to develop the international reach of the river by one of the four following schemes:

Scheme I. A two-stage development consisting of a dam at Ogden Island with a 27-ft. head, and one at Barnhart Island with a 54-ft. head. The total power capacity would be about 1,670,000 hp., the installation 2,352,000 hp. and the estimated cost $235,700,000.

Scheme II. A single-stage development at Barnhart Island with regulating dam at Ogden Island and a 75-ft. head similar to that recommended by the International Joint Commission in 1921. The total power capacity would be 1,565,000 hp. and the installation 2,240,000 hp. The cost was estimated to be $216,200,000.

Scheme III. A single-stage development at Barnhart Island with an 85-ft. head. The total power capacity would be 1,770,000 hp. and the installation 2,520,000 hp. The cost was estimated to be $206,900,000.

Scheme IV. A single-stage development at Barnhart Island with an 85½-ft. head like Scheme III, but with the ship canal on the American side. The total power capacity was estimated to be 1,790,000 hp., the installation 2,520,000 hp. and the cost $207,800,000.

San Joaquin Light & Power Corp., Fresno, Calif., is arranging a large expansion program during 1928. A new 110,000-v. transmission line will be built from the steam plant at Bakersfield to the Rio-Bravo substation. New substations will be constructed and installation of switching apparatus, hydroelectric station equipment and other items will be carried on.

The hardest game to play is the one that you are not interested in.

Testing the Refrigerating Plant

PART I. FACTORS AFFECTING TONNAGE. MEASURING AND WEIGHING AMMONIA. DETERMINATION OF HEAT BALANCE. BY W. R. WOOLRICH*

REFERENCE to the temperature-pressure curves of the Fig. 1, indicate the wide difference in operating characteristics of the commonly used commercial refrigerants. To be successfully used as refrigerants, however, each of these must be put through the same typical cycle. Pressures must be used that will supply the compressor with the refrigerant in gaseous form. Continuing on in the cycle, the pressures produced by the compressor must be such that the temperature of the gas is raised considerably above that of the available cooling water, otherwise condensation will not be possible at a working rate.

After condensation is complete, the liquid refrigerant is ready for expansion by lowering its pressure through an expansion valve, or, what might be more correctly called the pressure reducing valve. This lowering of pressure lowers the boiling point very greatly and makes possible the absorption of large quantities of heat as the ammonia boils in the cooling coils, revaporizes and takes up the latent heat of vaporization from the surrounding brine or air.

In this cycle, common to each of the several refrigerants, the tonnage produced is dependent upon:

1. The amount of refrigerant pumped through the system.

2. The pressure and temperature changes through which the refrigerant passes.

The parts of the system in which heat is gained are: (1) In the receiver and the piping between the condenser and refrigerator, (2) In the refrigerator, (3) In the piping between the refrigerator and compressor and (4) In the compressor.

The parts of the system in which heat is lost are: (1) In the jacket water of the compressor, (2) In the compressor-to-condenser piping and (3) In the condenser.

The heat equivalent of the work of compression added to the heat taken up in the cooler and the piping between condenser and cooler, and cooler and compressor represents, then, the total heat taken up. This must equal, then, the heat lost to the jacket water, to the compressor-to-condenser piping, and to the condensing water.

In this discussion, ammonia will be considered as the typical refrigerant, and the instructions given will apply specifically to ammonia systems. But the same general rules will apply to any of the other refrigerants shown in Fig. 1.

At certain temperatures and pressure ranges both ammonia liquid and ammonia gas would be present in parts of the refrigerating system. The heat content of the known weight of the ammonia liquid or of ammonia gas can be readily ascertained from the tables of "Properties of Ammonia" developed by the United States Bureau of Standards.

But when ammonia is present in both the gas and liquid form, it is not sufficient to know how many pounds of ammonia are being pumped, and at what temperature and pressure. In order to determine the total heat, it would be absolutely necessary to also determine the per cent of gas and liquid present.

Since such a determination would be very difficult under operating conditions, it is advisable to operate the plant under conditions that will assure the engineer that

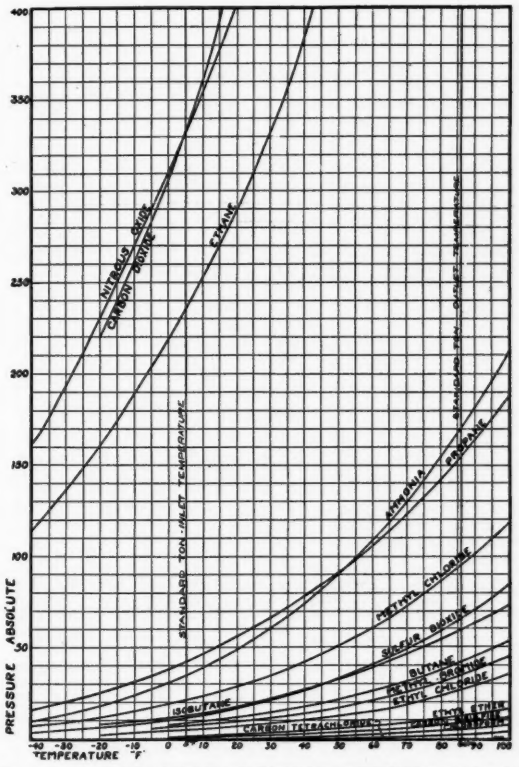


FIG. 1. TEMPERATURE-PRESSURE CURVES OF VARIOUS REFRIGERANTS

ammonia gas and ammonia gas only exists at the point of pressure and temperature measurement at the suction side of the compressor. Likewise, he must know that at the point of measurement of the temperature and pressure between the receiver and the expansion valve that only liquid ammonia is present.

To bring about this condition at each of these two points, under test conditions, the plant is operated under a few degrees of superheat at suction and a few degrees of sub-cooling at the receiver. If superheat is present at the suction then no liquid can be present. If a liquid is sub-cooled at the receiver then all of the gas must be condensed. It is for this reason that the stipulation is made under "standard ton" test conditions that 9 deg. F. of superheat shall be present on the suction side, and 9 deg. F. of sub-cooling shall be carried on the discharge side.

*Prof. of Mechanical Engineering, University of Tennessee.

Various methods are used to measure the amount of ammonia pumped through the system. The method used will probably depend on the degree of accuracy required.

If conditions require a test of closer accuracy than three per cent, the determination should be made by weighing the ammonia as it passes from the receiver to the expansion valve, or by measuring it by volume in tanks connected as auxiliary to the receiver.

If only an approximate test is desired, the ammonia

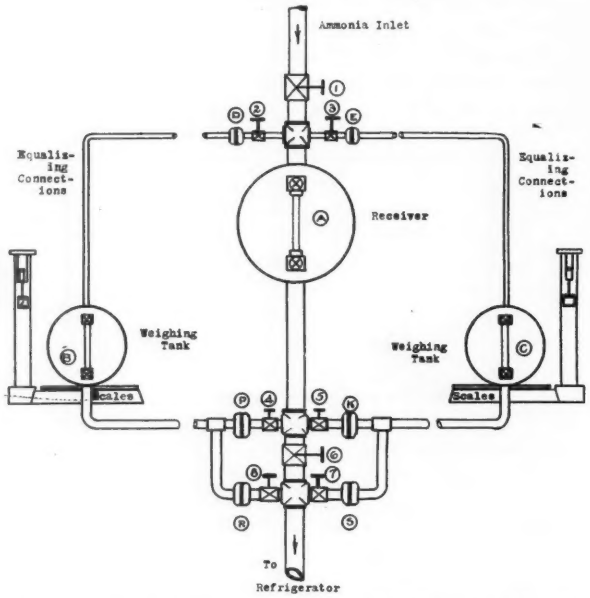


FIG. 2. APPARATUS SET-UP FOR WEIGHING AMMONIA WHILE OPERATING PLANT

The same set-up can be used for measuring the ammonia volumetrically by substituting calibrated measuring cylinders for the weighing tanks.

may be metered or the amount pumped computed from the indicator card. If either of these two methods is used, certain assumptions are necessary.

Still another method that can be used, if brine is circulated, is to measure the amount of brine cooled and the temperature rise and specific gravity of the brine. The specific heat of brine can be obtained from tables of specific gravity and specific heats. The product of the *brine circulated per hour*, multiplied by *specific heat* and this times the *temperature rise in the refrigerator* would give the value of the cooling effect produced.

How Ammonia Is Weighed

Ammonia can be readily weighed by connecting two cylindrical weighing tanks, as indicated in Fig. 2, permitting first one tank and then the other to function as the ammonia receiver, and using the regular receiver as a header to supply the two weighing tanks. The piping used in this set-up, contrary to the usual instructions, should be standard weight high grade steel pipe with a length of not less than ten or twenty feet, depending upon the size of connecting pipe that is necessary to carry the ammonia. It is not necessary to use extra heavy piping for this connection as is often specified. The standard weight pipe is more flexible, and new pipe is sufficiently strong to withstand the ammonia pressures at the temperatures met at the receiver.

In detail, the weighing operation using the layout of Fig. 2 would be as follows:

Under normal operation ammonia flows from the condenser to receiver A through valve 1, then through valve 6 to the evaporator or cooler by way of the expansion valve. When all is ready to start the test, one of the ammonia weighing tanks, say C, is partially filled by opening valves 5 and 3, with valve 7 tightly closed. When the gage glass of tank C shows sufficient ammonia, valve 5 is closed and the ammonia in tank C weighed.

The test can now be started. Valve 6 is closed, and valves 4 and 2 opened for filling tank B, while valve 7 is opened to supply the expansion valve. Throughout the test, valves 3 and 2 remain open as equalizing valves to permit tanks B and C to fill and empty freely.

Tank B is filled, then weighed in the same manner as tank C after valve 4 is closed. When ready to change tanks, valve 7 is closed and valves 8 and 5 opened to supply the expansion valve and tank C, respectively.

In closing the test, care must be exercised that all of the ammonia weighed has been discharged through the expansion valve.

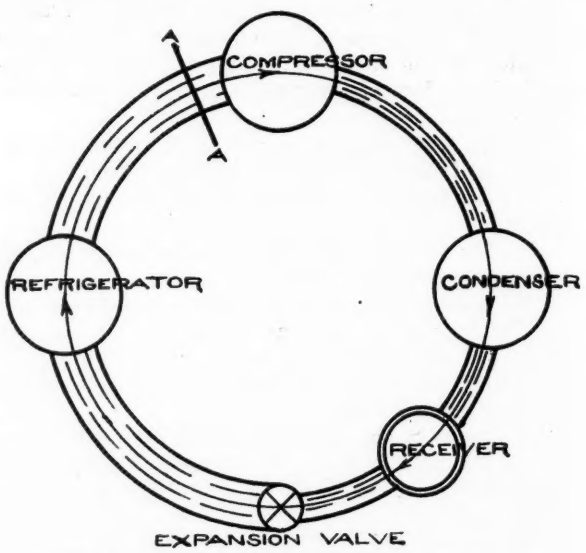


FIG. 3. TYPICAL CYCLE FOR REFRIGERANTS

In working out the heat balance, each pound of the refrigerant must contain the same heat content each time it returns to the same point of the cycle. If this were not so, there would be an accumulation of heat or cold in the system.

In setting up the equipment and piping for this test, it is especially recommended that the ammonia unions indicated as M. N. O and P be used. This will permit attaching and detaching the measuring equipment without delay.

How Ammonia Is Measured Volumetrically

Volume measurements of ammonia can be made that are fully as accurate as the weighing method. If weighing tanks B and C in Fig. 2 are replaced by vertical measuring tanks equipped with long gage glasses, the volume used can be correctly measured. The routine of filling these tanks is exactly the same as for weighing.

The data presented below giving a typical test of a 60-ton refrigeration plant has been collected on a plant in which the ammonia has been weighed as outlined in

Fig. 2. In addition to measuring the ammonia and the necessary ammonia temperatures, the amount of brine circulated has been metered and the temperature rise of the brine measured. This gives a check on the actual amount of cold produced in the secondary or brine system. The results obtained by computing the cold produced by the brine measurement method should be only a little less than would be shown when the results are obtained by measuring the amount of ammonia circulated and temperature produced.

Where direct expansion is not used, the brine method of refrigeration produced can be substituted with close approximation for the ammonia measurement method. The results obtained by the brine measurement method should differ only in the amount of heat picked up by the brine from sources other than the ammonia coils. For positive check the ammonia heat balance method is most desirable.

Figure 3 shows by means of a circle diagram the typical ammonia compression cycle. At any point A, in the cycle, as a starting point the sum total of B.t.u.'s gained by each pound of ammonia, from the time it leaves point A until it returns, must equal the sum total of the B.t.u.'s lost. If this was not so, there would be a rising or falling of the temperature in the ammonia system and eventually it would become too warm to produce freezing or too cold for the service required.

Data for Test of Single-Acting, 60-Ton Refrigeration Machine

1. Duration of test.....12 hr.
2. Average suction pressure (gage).....19
3. Condenser pressure (gage).....154
4. R.p.m. 225
5. Temp. of condenser water.....
6. Outlet .....73 deg.
7. Inlet .....60 deg.
8. Difference—inlet and outlet.....13 deg.
9. Weight of cooling water used per hr.....58,000 lb.
10. B.t.u. absorbed per hr. by cooling water..754,000 lb.
11. Temp. of brine.....
12. Inlet .....32 deg.
13. Outlet .....16 deg.
14. Temp. difference .....16 deg.
15. Specific heat of brine.....0.76
16. Weight of brine circulated per hr.....65,000 lb.
17. Cold produced in B.t.u. per hr.....790,400 B.t.u.
18. Ton capacity in 24 hr.....65.9 t.
19. Temp. of ammonia at compressor inlet....16 deg. F.
20. Temp. of ammonia at compressor outlet..233 deg. F.
21. Temp. of ammonia at condenser inlet.....92 deg. F.
22. Temp. of ammonia at condenser outlet....66 deg. F.
23. Temp. of ammonia at expansion valve....69 deg. F.
24. Temp. of ammonia leaving cooler.....11 deg. F.
25. Weight of ammonia circulated per hr.....1605 lb.
26. Refrigerating effect .....496 B.t.u.
27. Kw-hr. of current used per hour.....111
28. Kw-hr. used per ton of refrigeration per day...40.4
29. Indicated hp. of compressor.....86

Heat Balance

The heat balance should show:

Work of compressor.

Heat lost by compressor to condenser piping and to jacket water.

Heat lost to condenser.

Heat gained—condenser to evaporator or refrigerator.

Heat gained in evaporator or refrigerator.

Heat gained—evaporator-to-compressor piping.

Step by Step Solution for Heat Balance

(See Fig. 4 for diagrammatic chart of total heat values)

Work of compression:

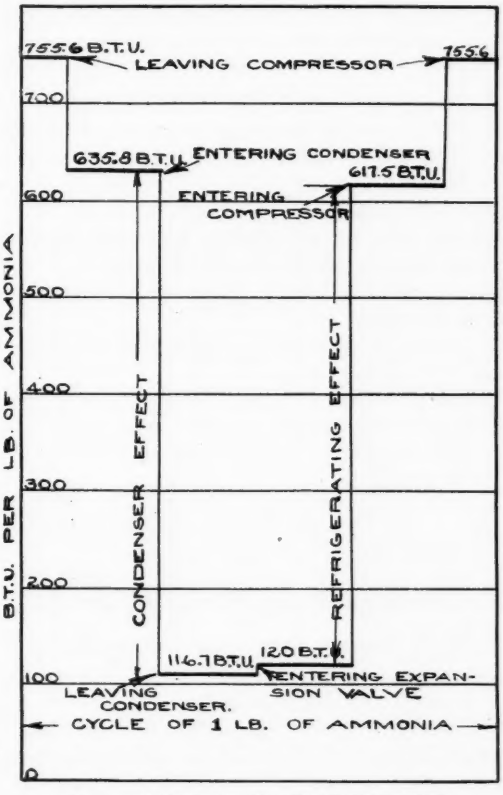


FIG. 4. DIAGRAM OF HEAT BALANCE

Values given on the chart correspond to the computed results of the heat balance given in the text matter. The relative heat values involved in each stage are shown in the diagram.

By item 29 the indicated horsepower is 86.

One hp. equals 2545 B.t.u. per hr.

Then the heat added by compression will be 2545 by 86, which equals 218,870 B.t.u.

Heat Lost in Compressor-to-Condenser Piping and to Jacket Water

The ammonia leaves the compressor at a temperature of 282 deg. F. at 154 lb. gage pressure. The heat in one pound of ammonia as it leaves the compressor will be made up as follows:

Heat of liquid at 154 lb. gage pressure	138.7 B.t.u.
Latent heat	492.8 B.t.u.
Superheat	124.1 B.t.u.
	755.6 B.t.u.

When the ammonia enters the condenser it is at 92 deg. F., according to the test data given. The heat in one pound of ammonia at 17 lb. gage and at 92 deg. F. is as follows:

Heat of liquid at 154 lb. gage	138.7 B.t.u.
Latent heat	492.8 B.t.u.
Superheat	4.3 B.t.u.
Total	635.8 B.t.u.

The heat lost per pound is the difference of the two superheat values, or 124.1 — 4.3, or 119.8 B.t.u.

The heat lost by 1605 lb. of ammonia circulated per hour will be 1605 × 91.1 or 192,279 B.t.u.

Heat Lost to Condenser

Temperature of gas entering condenser is 92 deg. F.

Temperature of ammonia corresponding to pressure of 154 lb. is 85.8 deg. F.

Superheat in deg. is 92 — 85.8 or 6.2 deg.

The total heat of one pound of ammonia gas entering condenser is 635.8 B.t.u. as outlined above.

The temperature of the ammonia at the condenser outlet is 66 deg. F.

The total heat of ammonia liquid at 154 lb. gage and 66 deg. F. is as follows:

Heat of liquid	116.7
Latent heat	0
Superheat	0
Total	116.7 B.t.u.

The heat lost in the condenser will be, then, for each pound of ammonia, 635.8 — 116.7, or 833,155 B.t.u.

Heat Gained—Condenser-to-Evaporator

Temp. of ammonia at inlet to cooler	69 deg. F.
Temp. of ammonia at outlet of condenser	66 deg. F.
Difference	3 deg. F.

Since the specific heat of liquid ammonia at this pressure is 1.12, the heat gain per lb. of ammonia will be: 3 × 112 = 3.36 B.t.u. The heat gained by 1605 lb. of ammonia will be 1605 × 3.36 B.t.u. or 5400 B.t.u.

The total heat in the ammonia per pound will then be 116.7 added to 3.36, or 120 B.t.u.

Heat Gained in Evaporator

The heat gained in the evaporator is equal to the heat in the gas leaving the cooler less the heat in the ammonia entering the cooler.

Temperature of liquid ammonia entering the evaporator	69 deg. F.
Heat of liquid entering evaporator is	120 deg. F.

The heat of the gas leaving the evaporator at 11 deg. F. and 19 lb. gage is as follows:

Heat of liquid	47.6 B.t.u.
Latent heat of evaporation	565.5 B.t.u.
Superheat	4.4 B.t.u.
Total	617.5 B.t.u.

Heat gained per lb. is 617.5 — 120, or 497.5 B.t.u.

Heat gained by 1605 lb. is 1605 × 497.5 or 798,487 B.t.u.

Heat Gained in Evaporator-to-Compressor Piping

Total heat of gas leaving evaporator	617.5
Total heat of gas entering compressor	619
Heat gained per pound of gas	1.5

Total heat gained is 1605 × 1.5, or 2407 B.t.u.

Calculations of Test

No. 8 = No. 6 — No. 7 73 — 60 = 13 deg. F.

No. 10 = No. 8 × No. 9 13 × 58,000 = 754,000

No. 14 = No. 12 — No. 13 32 — 16 = 16

No. 17 = No. 14 × No. 15 × No. 16 16 × 0.76 × 65,000 = 790,400 B.t.u.

$$\text{No. 18} = \frac{\text{No. 17} \times 24}{288{,}000} \quad \frac{790{,}400 \times 24}{288{,}000} = 65.9 \text{ tons}$$

No. 26 = 617 — 121 = 496 B.t.u. (From tables)

$$\text{No. 28} = \frac{\text{No. 27} \times 24}{\text{No. 18}}$$

$$\text{No. 28} = \frac{24 \times 111}{65.9} = 40.4 \text{ kw-hr.}$$

Check of No. 18 by Heat Balance:

Heat gained in evaporator per hr., 798,487 B.t.u. from heat balance.

$$\frac{798{,}487 \times 24}{288{,}000} = 66.5 \text{ tons}$$

Heat Balance

	Heat gained	Heat lost
Work of compression	218,870	
Radiation from compressor-to-condenser pipe line		192,279
Heat lost to condenser		833,155
Heat gained condenser-to-evaporator pipe line	5400	
Heat gained in evaporator	798,487	
Heat gained evaporator-to-compressor pipe line	2407	
Total	1,025,164	1,025,434

To determine to what extent and in what manner electricity is being used on the farms of Texas, a survey of 505 farms in that state in 53 counties has been made by the Texas Committee on the Relation of Electricity to Agriculture, according to a recent announcement by T. O. Walton, chairman of the committee. The work was carried on by J. E. Waggoner, director of the committee, and the report shows that 63.1 per cent of these farms averaged 18.44 kw-hr. of electricity per month consumption. The general average of the 505 farms is 169.4 kw. a month.

Southwestern Gas & Electric Co., Shreveport, La., is reported planning the construction of a new steam power plant in the northern section of the state, to cost about $1,500,000.

Principles and Design of Surge Tanks

PART I. FUNDAMENTAL PRINCIPLES OF TANKS USED BY HYDRAULIC POWER PLANTS AND METHOD OF COMPUTING SIMPLE TANK SIZE. BY JOHN S. CARPENTER

BRIEFLY DESCRIBED, a surge tank is to a water power plant having a long pipe line what a flywheel is to a single cylinder steam or gas engine. It smooths out the impulses; when properly designed, when there is a momentary excess of power, the surge tank absorbs it and by so doing it slows up the advancing water column in the pipe line; when there is a deficiency of power, it gives out power by letting some of the stored water flow out to meet the temporary shortage and this action of giving out some of the stored water accelerates the water in the pipe line to flow faster and restore balanced conditions.

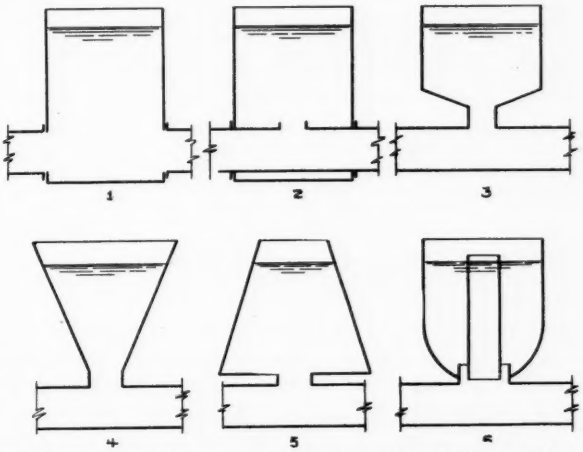
Structurally, a surge tank is a means of holding a large quantity of water; it is connected to the pipe line and is preferably placed as near to the power house as the topography of the country will permit. To reduce costs, the surge tank is often set on a nearby hill so that it is not necessary to build as heavy a steel or concrete supporting structure for the enormous weight of the tank and contents.

FORMS OF SURGE TANKS

Many forms of surge tanks have been built. There is the so-called "simple tank" in which type the pipe line is connected to opposite sides of the lower part of the tank and the water thus flows through the tank in going to the water turbines. See Fig. 1. Next are the so-called "throttling" types, in which the water encounters resistance to flow in going into or out of the tank. The throttling type covers the rest of the types in general use, in a broad sense. The basic principle is to provide means of quickly damping out the surges of the simple tank, which, for dampening purposes, has only the pipe friction and other minor frictional effects to break up the wave action. Thus it is readily seen that the inherent characteristic of the simple tank is to keep up its surge action for a comparatively long time, although, if the tank is large enough, even slow acting hydraulic governors can keep step with the slow wave cycles. The effect of such long continued variation of the head level in the tank is to induce corresponding changes in the generator speed, taking a long time to come to rest. No attempt will be made to predict the effect of several sudden heavy load changes coming in quick succession, such a happening being indeed possible, but with any design of tank now known, an extremely serious matter.

An almost ideal surge tank, in the rare instances when available, is a large lake or storage pond which is located near enough so the deficient water can be quickly got to the turbines.

Figure 2 shows a type of tank having a restricted orifice between the pipe line and the surge tank. The effect of the restricted orifice is to make available almost instantly a large accelerating or retarding head for controlling the flow in the pipe line. In a simple tank, we have the same results, but it is much slower getting into action and the large masses of water in the simple tank have an overrunning effect; in other words, the heavy body of water must be started and having reached the desired degree of motion, it should, theoretically, be stopped right there, but the great masses to be handled will not admit of this and will overrun the desired point and have to be brought back one or more times. This introduces an important matter of surge tank design: "Following a given maximum load change, when will the head level in the surge tank come to a final and steady value?"



FIGS. 1—6. DIAGRAMS SHOWING FUNDAMENTAL CONSTRUCTION OF TYPES OF SURGE TANKS NOW IN USE

1—Simple tank.
2—Tank with restricted orifice between pipe line and tank.
3, 4 and 5—Variations of the restricted orifice type.
6—Johnson differential surge tank, employing riser.

In the restricted orifice type of tank the size of the orifice determines the character of the surges. If made the same diameter or the same area as the pipe line, it is evident that then we have a simple tank, as the restricting property is not there. If the area of the orifice is made very small in proportion to the pipe area, we approach the condition where we have no surge tank at all. Somewhere between these two wide limits, there is a proportion of areas that will give quick retardation and satisfactory acceleration.

Figures 3, 4 and 5 show variations of the restricted orifice principle. Figures 1, 2 and 3 show tanks with constant cross-sectional area through their heights. Figures 4 and 5 show tanks of varying areas, to accomplish special conditions assumed. Figure 6 shows a diagrammatic section of the Johnson differential surge tank, patented by R. D. Johnson of Philadelphia. The world owes Mr. Johnson a great debt for his work in this line, especially for the great care with which he has investigated and given to the public the results of his labors in surge tanks, water hammer, etc., and their complicated phenomena. The Johnson surge tank has a riser in the center of the tank, and usual constructions show ports at the lower end connecting the pipe line directly with the storage tank. An elementary description would

be given as follows: In case of load rejection by the turbines, the water rises quickly in the central riser and no doubt in most cases spills over into the larger tanks, thus quickly providing a large decelerating means and so slowing down the water effectively to the new conditions demanded. Some water, in the meanwhile, has bypassed directly from the pipe line into the outer storage tank. In case of demanded load, the water level in the riser falls very quickly and thus provides an accelerating head to speed up the water in the pipe line and while also bypassing water directly from the storage tank into the pipe line. This hardly does justice to Mr. Johnson's ingenious device, our space not allowing more.

Dead Beat Action

A most desirable feature in a surge tank is dead beat action, in which the water level, after a load change on

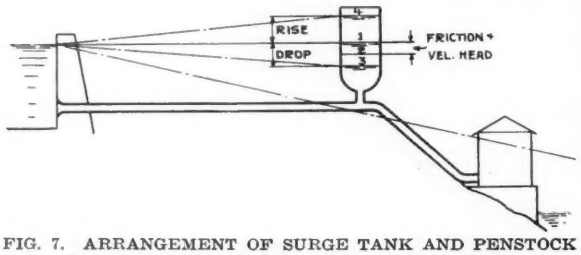


FIG. 7. ARRANGEMENT OF SURGE TANK AND PENSTOCK FOR WHICH COMPUTATIONS ARE GIVEN IN TEXT

the turbines, moves to the correct final position demanded by the new load conditions without dancing up and down for a great length of time. This action, as here described, is quite ideal and in most tanks is accomplished in degree only. The simple tank has little inherent dead beat action unless made extremely large in area, so that the head varies only within small amounts.

Computation of Simple Tank Size

We shall now take up the design of the size of a simple tank, to start with, using a simplified analysis that has been tried out practically, based on the "load on" demands of an isolated plant. The worst condition that could arise in this regard is to have the unit take its full load suddenly, which condition can be realized in practice in extreme cases, but is seldom liable to occur. The unexpected case of full load demanded suddenly involves the safety of the pipe line as regards collapse, and unless matters are definitely arranged so that this case is impossible, it had better be taken as the basis of design in the isolated plant. Where there is much interconnected load, conditions are, of course, modified.

The following method is not claimed to be rigorously exact, and is open to technical objections. Other elements intervene, however, and later we shall compare this design with a carefully computed analysis using higher mathematics. Let us assume an arrangement as shown in Fig. 7 and assume data as follows:

Length of flow line from dam to surge tank, L, 5000 ft. Area of flow line, A, 100 sq. ft. Effective head on turbines, H, 50 ft. Full load discharge or demand of turbines under normal head is Q, 500 cu. ft. sec. Time, t, of governor in closing or opening gates is 3 sec. It is a given condition that the tank shall not spill in case of full load rejection, such as might follow a short circuit. In case of sudden demand for full load, the surge tank must not drain and for our case it is specified that the maximum drop of head level in the tank shall not exceed 20 ft., including friction and velocity heads. Our tank will be of the simple type shown in Fig. 1.

The very first step is to find out how fast the water in the flow line can be speeded up to the full load velocity of 5.0 ft., as would be the condition for sudden full load demanded. Assuming, for the present, that the full 20-ft. drop in surge tank level can be used to accelerate the flow line velocity, the theoretical time in which the water can be accelerated from 0 to 5 ft. velocity is given by:

$T = v\,L/hg$, seconds, or $5 \times 5000/20 \times 32.2 = 38.8$ sec.

Tests and experience show that to keep the drop as specified we shall have to increase this theoretical time 55 per cent, making the actual time 60 sec. Our water load curve will then look something like Fig. 8. The capital letter A in the upper triangle shows the demand on the tank during the period of acceleration in the flow line and the lower triangle shows what it is assumed that the pipe line will supply during the same time. We note

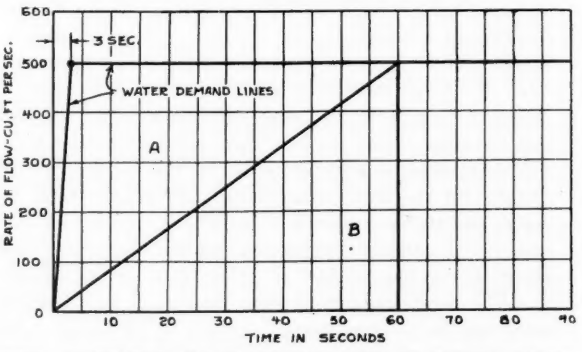


FIG. 8. WATER LOAD CURVE FOR PROBLEM ILLUSTRATED IN FIG. 7

that the governor action in opening the gates in 3 sec. causes a slight reduction in the area of the upper triangle as against the lower, but here we shall ignore this.

We are now in a position to figure the capacity of the surge tank. The area of the upper triangle in Fig. 8 is, neglecting the small 3-sec. part, as before mentioned, is obviously:

$$\tfrac{1}{2} \times 500 \times 60 = 15{,}000 \text{ cu. ft. sec.}$$

The friction head in the flow line carrying 500 c.f.s. will be about 3.5 ft., depending on pipe material and construction, and the velocity head will be .39 ft. As we are now to calculate the diameter of the tank, we shall here include the friction and velocity heads, which total nearly 4.0 ft., which value we shall deduct from the 20-ft. drop in surge tank level already specified. The difference is 16 ft., and the foregoing 15,000 cu. ft. sec. must be contained within a tank height of 16 ft. This then requires an area, in the tank cross section, of 938 sq. ft., equivalent to a diameter of 34.6, say 35 ft. diam.

We now have a solution and in our next paper, to follow this, we shall point out some of the defects of this simple, though really effective, calculation method.

(To be continued)

Roller Guides Rope on Hoisting Drum

MEN IN CHARGE of mine hoisting machinery often find it difficult to get the rope to stow well on the drums; this is particularly true in the case of long hauls and with drums that are not grooved to receive the first layer of rope. With this first layer not stowed well, the rope is likely to pile up to one side of the drum or in the center; this pile then spreads out or falls over, with the result that the leading part of the rope is caught under some of the other turns, resulting in considerable delay in getting the rope out of this tangled condition and often the rope is somewhat damaged.

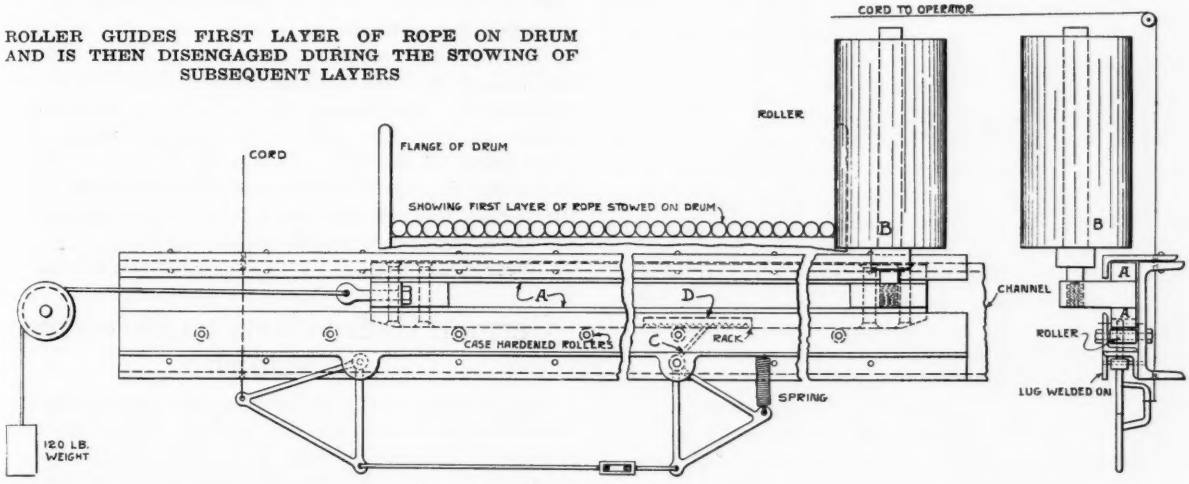
For some time we have had this trouble at one of our mines; the haul here is somewhat over 11,000 ft., running at an angle of 15 deg. The rope used is 1¼ in. diameter, the diameter of drum is 11 ft., width of drum face is 3 ft. 9 in. This drum has a plain face and often the rope would stow badly.

The device shown in the accompanying sketch was designed by our shop superintendent, Arthur P. Rees. Its operation is as follows: When the car, which carries 20 t. of ore, is at the bottom of the slope, we generally have three turns of rope on the drum. A slide, "A", carrying a roller, "B", is fitted and free to move in guides fastened to a 9-in. channel and secured to the wall in front of each drum. A weight is attached to the slider by a piece of ⅜-in. flexible rope passing over a 10-in. pulley.

In starting away from bottom of slope the roller is pressing against the rope because the slider is free to move with the weight. As the drum rotates, each turn is stowed in its place until the drum is covered by the first layer. As the rope starts to make the next layer, the slider is caught by pawl, "C", in rack, "D", and disengaged. Now the first layer being well stowed, grooves for the next layer have been formed, and so on for all of the nine layers.

On the return down the slope, the roller is held disengaged until the last layer begins to unwind; then the operator trips the pawl and the roller follows the rope back to the place of starting and is ready for another trip.

ROLLER GUIDES FIRST LAYER OF ROPE ON DRUM AND IS THEN DISENGAGED DURING THE STOWING OF SUBSEQUENT LAYERS



The only extra work the operator is called upon to do is to trip this pawl once in each run. There are several other rigs that might be used for this purpose, but one that can be held clear of the rope after the first layer is stowed is by far the best as it saves wear on both the rope and the roller.

Bell Island, Newfoundland. J. B. PETRIE.

Reflection Aids Head Work

POUNDING in a compressor developed in our plant and after the compressor was shut down the cause was found to be due to a broken valve on the crank end, part of which valve was not to be found. So we concluded that the part had dropped into the cylinder. The machine had poppet valves and, although we could get our arm and hand into the port, we could not reach the bottom of the cylinder to get hold of the missing piece or pieces.

Before taking the head off, one of the helpers suggested that we drop a magnetized bar through the port, using a small mirror and extension light to illuminate the

bottom of the cylinder. By holding the mirror at an angle, we were enabled to locate two small pieces of the valve. Then, by lowering the bar on one piece at a time, it was an easy matter to lift it out with the bar.

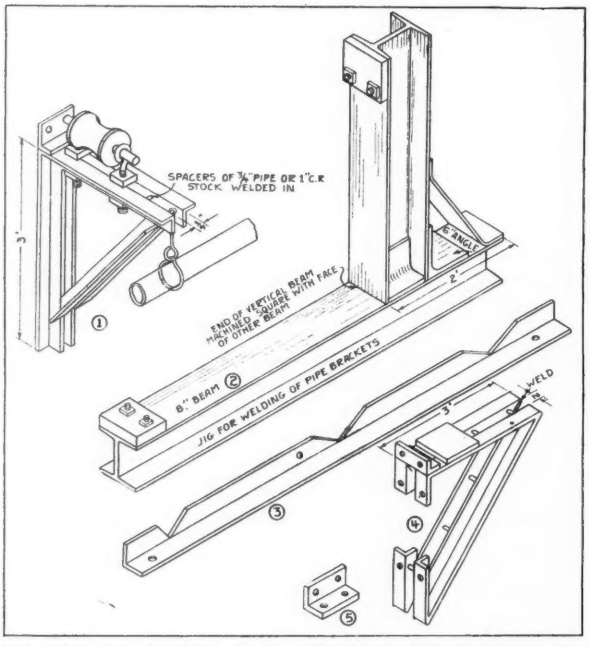
Another interesting application of a mirror and extension light was in the removal of old packing from a deep packing box before repacking.

Sometimes you think you have the old packing all out when such is not the case. By throwing the reflected light from the mirror into the box, you can see the bottom of the box plainly and you can make sure that none of the old packing remains to interfere with the proper working of the new packing.

Hollyburn, British Columbia. JAMES E. NOBLE.

Pipe Brackets Made of Welded Pieces

PIPE BRACKETS for supporting four long lines of pipe, respectively, 12 in., 4 in., 2½ in. and 2 in. in diameter, were very satisfactorily made of 3 by ¼-in. angle iron



JIG AIDS IN ASSEMBLING PARTS FOR ARC WELDING TO FORM PIPE BRACKETS

by cutting and arc welding the joints for use in a power house. Two types of brackets were made as illustrated; one type being made of one piece bent up and welded as shown at 4, the other type being made up of pieces welded together. This latter type required more cutting and welding than the other type.

In order properly to hold the pieces while being welded, a jig, shown at 2, was made. The bracket is assembled in this jig and tack-welded. The base of the jig is a piece of 8-in. H beam about 6 ft. long. The upright is about 4 ft. long and one end is sawed or machined square with the face. The braces and other parts of the jig should be riveted or bolted into place so that they cannot move. If desired, these parts may be arc-welded together. A jig of this kind will be found useful on construction work in lines for which it was not intended. The end blocks are attached by bolting, in order that they may be removed if it is desired to use the jig for other purposes. It is convenient to lay out a pattern to exact size and shape on light weight galvanized iron and cut this out and bend it to check up the cutouts.

After having determined the proper shape and amount of the cutouts, the angle iron is prepared for the first type of bracket as shown at 3 by use of the galvanized iron template, the angle iron being marked in the proper places by means of a soapstone pencil and the markings prick punched.

Cutting is done with the cutting torch and bending is aided by use of the torch. Additional trimming is usually necessary, in order to secure a good fit on the jig. A couple of heavy clamps and a bending bar will aid in bringing the sides of the bracket to a good fit on the jig. The sides of the bracket are built in pairs; one right; the other left.

After the sides of the bracket are bent sufficiently to fit the jig, the spacer should be placed between the two sides of the bracket and the whole securely clamped. All parts should then be securely tack-welded together. The bracket should then be removed from the jig and the welding completed.

Drilling the bracket is best done after all welding has been completed, including the welding on of the top brace 5. The bearing plate is of ¼-in. boiler plate neatly cut with the torch to the desired length. The other parts of the bracket were made by the welder, the torch being used where necessary for heating. After the second day, one man and a helper were able to turn out three complete brackets per day of 8¾ hr.

Springfield, Mass. A. S. JAMIESON.

German Hydro-electric Conference at Munich

On January 4 and 5 I was a guest at the German Hydro-electric Conference at Munich. Before the Conference it was expected that they would adopt a hydro-electric test code. At the conference, however, the first day was spent organizing and deciding upon the general policies to be followed, and it was decided that the work done by the International Electrical Commission at Bellagio, Italy, last summer would be taken as a basis and a guide only and that changes in that preliminary code could be made.

There were, of course, many prominent and well known hydraulic engineers present and, after an entire morning deciding on policies to be followed, the work was divided up and committees appointed to work up the code of each of these parts. A co-ordinating committee was appointed to receive and iron out any differences between the committees, so that it is probable that the work will not be done before the first of next year. Prof. Dr. Ing. D. Thoma was the outstanding man at the conference. In the January 25 issue of V. D. I. Nachrichten there is a picture of the notables present and a short writeup of the affair.

One of the most interesting parts of the meeting was a discussion following the presentation of a paper by Prof. Lutschg of Zurich, in which he claimed that the salt or chemical method of water measurement was accurate to within 0.5 per cent. Many took issue with him

regarding this, and particularly Prof. Dubs, with whom I am inclined to agree. He maintained that any of the water measurement methods are very accurate when you know what the answer is, but that when you do not, it is impossible to know how accurate they really are.

What leads me to agree with his conclusions more than anything else are the recent experiments I have seen on weirs and orifices in Prof. Thoma's laboratory at the Technische Hochschule. For example, he has a nozzle, and when he starts the water flowing through it suddenly he gets one coefficient, but after stirring the water up with a stick, the coefficient cannot be duplicated within 10 per cent. The type of flow affects practically every water measuring method.

On the first evening of the conference, there was a very enjoyable banquet; the second day was spent visiting the Mittlere Isar plants, of which Pfrombach was one. When we got there, however, it was raining and cold so that it was possible to make only a most casual inspection, because of the mud and disagreeable weather. The dam and most of the foundation work of the power house are now complete.

The social side of the conference was extremely interesting and important for all concerned. You see all of this work must be done voluntarily and no one except the V. D. I., who sponsor it, receives any credit; those who help are given a kind of professional holiday among men who are thinking and doing the same thing.

Munich, Germany. BLAKE R. VANLEER.

(Editor's Note: The foregoing paragraphs were taken from a personal letter to one of the editors of Power Plant Engineering. Prof. Vanleer is Assistant Professor of Mechanical Engineering at the University of California and has been in Europe since last June as one of the A. S. M. E. selections to the John R. Freeman Travel Scholarship Fund.)

Why the Boiler Efficiency Is Low

WHILE VISITING a plant to renew acquaintance with the chief under whom I had previously worked, I found a new engineer in charge. He showed me around the plant and I noticed all of his boilers were in operation and at once asked him the reason, for I knew the factory was not running at full capacity and the old chief had carried the peak loads with one boiler cut out all the time. I received from the new engineer a few pointers about boiler economy that were decidedly novel even if they were not correct.

"Yes, I know the load can be carried on the two water tube boilers, with the three return tubular boilers shut down if we have to," he said, "but if we did that the fireman would have to fire up oftener and then we would have to hire a coal passer as the fireman would have no time to wheel in his coal. The coal consumption would increase because firemen always burn more coal if someone else brings it in for them."

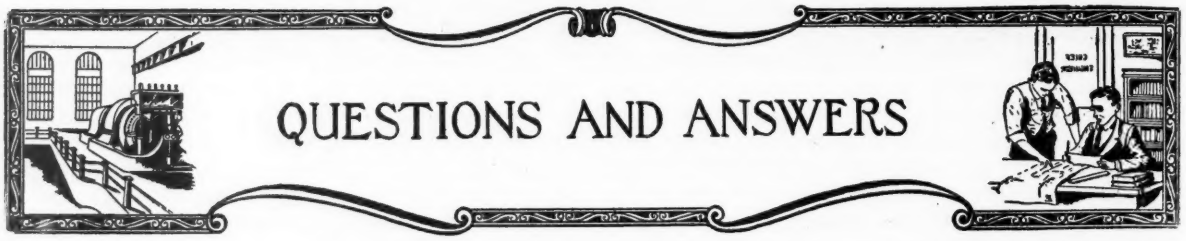
No mention was made of the comparative efficiencies of the old return tubular boilers with their leaky settings and low furnaces and the water tube units with modern settings less than 2 yr. old. He just arbitrarily assumed that by making the fireman wheel coal, less fuel would be burned. No consideration was given to what the boilers themselves were capable of doing nor to the fact that either design was a great improvement over the other. It is safe to say that 10 per cent higher efficiency could be secured from the water tube boilers and, with a fuel bill of $3000 per month, the higher efficiency would easily pay for a coal passer and leave a substantial net saving.

Another plant in this vicinity changes firemen constantly. One day the engineer asked me to recommend a good fireman. He informed me that he did not care to have a man who was always "fussing" with his fires as he had just fired one of his men for that reason. "I allow a man to take 15 min. each hour to fix up his fires, then the fire needs no further attention for 45 min. and I expect the fireman to spend these 45 min. of each hour helping me in the repair shop. If a man does nothing but attend his fires it costs us about $100 a month for an extra helper in the shop." The system of firing in his plant was to shovel 20 scoops of coal into each furnace at one firing period, firing at one-hour intervals. It is therefore clear why they had more visits from the local smoke inspector than any plant in the city. Roughly, a ton of coal is fired in this way every hour for nine hours a day, at least one ton out of the nine being preventable waste.

These errors are by no means confined to small plants, as a large textile plant in this locality, having 3000 b.hp. allows the discharge water from the condenser to run into the river at 70 to 80 deg. and then pumps makeup water for the boilers from this same river at a temperature of 40 to 60 deg. To prevent economizer tubes from sweating, 6000 lb. of live steam per hr. has to be used in the open feedwater heater, due to the low makeup temperature in winter months. An economizer was installed in another plant and the engineer told his firemen that he expected a feed temperature of 275 to 280 deg. all the time. This was maintained until a new fireman came on the job and it was noticed that on his shift the temperature dropped over 10 deg. He was promptly told that this would not be tolerated, but he pointed out that the coal per kw-hr. record was actually reduced on his shift in spite of the reduced feedwater temperature. Upon investigation it was found that he carried better fires than the others, using much less excess air, which meant that the weight of gases passing over the economizer was naturally less and there was less heat in the flue gases to be given up to the feedwater.

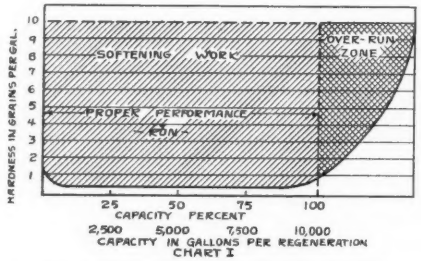
A friend of mine put a barrel of soda ash into two vertical fire tube boilers and removed 20 wheelbarrowfuls of scale which was ½ in. thick at the lower end of the tubes. Immediately he had about 100 tubes leaking and about 20 had to be renewed at a cost of $500. In one place nothing but the scale itself was holding against the boiler pressure of 100 lb., yet the engineer was called on the carpet and informed that he had spent more for repairs in two months than his predecessor had in 3 yr., and that his services were no longer required. The fireman admitted that the coal consumed per shift has been a ton less and as the coal cost $8.00 a ton the savings amounts to $4500 a year, assuming the boilers were kept clean thereafter. A fuel loss of $4500 was accepted with better grace by the owners than a necessary repair bill of $500.

Springfield, Mass. A. F. SHEEHAN.



Effect of "Starving" Zeolite

In your March 1, 1928, issue, page 312, there is a question and discussion on the subject of overloading zeolite softeners. The writer believes he can throw some further light on this discussion and at the same time call attention to the improper use of the term "non-porous zeolite."



CHARTS SHOWING EFFECT OF OVER-RUNNING A ZEOLITE SOFTENER ON THE AMOUNT OF SALT REQUIRED FOR REGENERATION

Work done by a zeolite water softener is usually measured in terms of grains-gallons. The grains refer to grains per U. S. gallon of hardness in terms of calcium carbonate and the gallons to the measure of water softened to about ½ grain or less. Chart I is the "work diagram" of a zeolite softener rated to soften 10,000 gal. of 10 grain hardness water, and the "softening work" is that of the area of the rectangle of 100,000 grain-gal. The salt required to do this work is usually ½ lb. per 1000 grain-gal. of softening work done. In this example, the salt required is 50 lb.

It is obvious that all of the exchangeable sodium of the zeolite is not used up if the softener is stopped and regenerated at the 10,000 gal. mark. If the zeolite is continued in service, however, after the 10,000 gal. mark is reached, the hardness of the effluent gradually rises, the curve turning upward more and more rapidly all the time until the effluent is the same in hardness as the influent. This practice is not to be recommended under usual conditions. Where this practice is followed, it is known as "starving" the zeolite rather than "overloading" it. The result of over-running or starvation is shown by chart II. In this chart the full line curve shows the type of softener performance to be expected following one or more starvation runs using the same charges of salt, viz., 50 lb. for each regeneration. The amount of no hardness water is reduced materially from the 10,000 gal. to something over half. Thus the salt used per unit of softening work done is materially increased.

There are two ways to restore the zeolite to its rated performance. One way, which is usually slow, is to cut the softener out of service the instant effluent begins to show some hardness and regenerate with the 50 lb. of salt. With 5 to 10 cycles of operation the capacity will gradually build up, in this manner, to rated performance. Another way, much quicker than the first, is to regenerate with an excess of salt, using say 75 or 100 lb. instead of 50. Or, better yet, perform two regenerations, one right after the other, without doing any softening work with the zeolite between the two.

When a zeolite fails in efficiency due to a short period of starvation run, usually one of the above methods will effect proper restoration of performance. If the starvation has been practiced so long as to constitute abuse, more radical treatment is necessary and this should be resorted to only under the supervision of the manufacturer of the zeolite. Sometimes a zeolite becomes so badly starved that it will not respond to any treatment and must be replaced. Nearly all zeolites have a greater capacity for softening than that stated by the manufacturer as the rated performance. Always more soft water can be obtained if a greater amount of salt is used per regeneration. But the chances are the operator will find that although he gets more soft water by using more salt, the relation of the soft water secured to the salt used is not as good as that obtained when the manufacturer's rated performance is the basis of operation. The zeolite softener is much like a storage battery—it must be kept charged up to the equal of the work expected of it; work is not done for nothing. More salt must be used than the instructions call for if the zeolite is overrun, and a zeolite softener is over-run when it has delivered more water than that for which it is designed, or when it has delivered its rated capacity but operating on an influent of a higher hardness than that for which it is designed.

Operators will have better results and more economical use of salt if they will check frequently the hardness variation of both the influent and effluent. Such a check is a far better guide than the meter which records merely the gallons passed and not the condition of the effluent. More gallons can be softened, if the influent hardness is reduced. Thus in the example, if the influent hardness reduces to 5 grains, the capacity can go safely to 20,000 gal. But if it increases to 20 grains, then the capacity should be reduced to 5000 gal., etc. In all variations, the product of the hardness and the gallons

should be a constant. Furthermore, so long as this one constant is the basis of operation, the same amount of salt should be used for each regeneration.

The answer published in your March 1 issue also involves the terms "porous" and "non-porous" zeolites. No such thing as a non-porous zeolite is known to exist. The use of such a term is both confusing and improper and the writer challenges it. The pores of a zeolite are ultra-microscopic in size. In the present commercially used zeolites, porosities range from 20 per cent to 40 per cent measured as water weight absorbed compared to zeolite weight at 100 deg. C.

As might be inferred from the answer, porosity, on the contrary, has no relation to the weight, because a zeolite of greater porosity might also be of greater density and thus, volume for volume, might weigh more than the less porous one. Although porosity can be determined readily, usually after it is measured, it bears no particular significance, mathematically or otherwise, in relation to the capacity of exchange.

So-called clogging of the pores is just plain "bunk"—but the more or less complete deposit of a foreign substance on the grains of a zeolite is a sad and discouraging affair. Thus the operator should supply to his zeolite softener only clean clear water. Oily, or organic matter and the after precipitate from improperly treated or filtered water are nearly always disastrous to any zeolite. It is likely that this would be equally true with a "non-porous" zeolite, even if there were such a thing.

Chicago, Ill. W. J. HUGHES.

Engine and Boiler Problems

WITH A VIEW to obtaining a higher grade license, I am studying the subject of engines and boilers. I find some questions that I have been unable to have answered and am asking if you cannot help me.

1. What is the advantage of a uniflow engine? What is claimed for it?

2. What causes a lubricator to get hot?

3. What is the force tending to rupture the girth seam of a boiler 72-in. diameter, when working under a pressure of 100 lb. per sq. in.?

4. Why do they take card readings at the points of release and compression? J. O. L.

A. The distinguishing feature of the uniflow engine is that the steam in the cylinder always moves in one direction hence its name "uniflow," meaning one directional flow. The advantage of this is that, since the cylinder walls at any one point are not alternating between admission steam temperature and exhaust steam temperature, the steam retains its heat better and, therefore, there is less condensation; the steam enters the cylinder at the hotter end and exhausts where the walls are cooler due to the expansion of the steam.

2. Details are lacking in your question. If you have a hydrostatic lubricator, it is quite likely that you are feeding the oil too fast, the steam entering the condensing chamber may condense but the condensate does not have time to cool and will heat the lubricator.

3. The longitudinal tension, which is equal to the force tending to rupture the girth seam of a boiler is caused by a force equal to $D^2p \div 4$ where D = average diam. of shell and p = pressure in lb. per sq. in.

The force will therefore be $= 3.1416 \times 72^2 \times 100 \div 4$, or, in round numbers, 408,000 lb. total pressure.

To get this in the form of unit pressure, it is necessary to know the thickness of the pipe. The cross sectional area will then be equal to

$$[(D + d) \div 2]\ t$$

where D = outside diameter of pipe
d = inside diameter of pipe
t = thickness of pipe in inches.

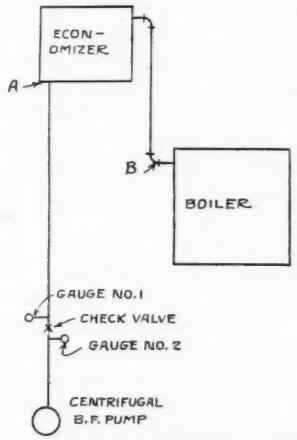
If, then, we divide the total pressure, 408,000, by the cross-sectional area thus obtained, we will obtain the pressure in lb. per sq. in.

4. The theoretical curves of expansion and compression are laid out, beginning at the points of release and compression respectively. The relative positions of the actual and theoretical curves indicate whether or not you have a leaky piston.

Static Head Influences Gage Readings

WILL YOU kindly answer the following questions?

1. As shown in sketch, would gage No. 1 have to be corrected for a static head to the top of the economizer or for a head where water enters the boiler?



CHECK VALVE PREVENTS OPPOSITE FLOW BUT DOES NOT AFFECT POSITIVE PRESSURE

2. With a check valve in the line as indicated, would gage No. 2 have to be corrected for static head or would the check valve eliminate necessity for correction, considering the pump to be running? F. S.

A. To obtain the pressure at the entrance to the economizer, it is necessary to correct either gage for the height in feet to A, as shown in Fig. 1, divided by 2.31. The check valve has no influence on the pressure shown by gages in the line under the check valve.

Flow through the economizer is accompanied by a certain amount of friction, therefore, to obtain the pressure at entrance of boiler B, it is necessary to correct for the height to B minus the friction due to passing through the pipes in the economizer, that is the difference in the heights of A and B is balanced in the up and down pipes.

EDITORIAL COMMENT

The Capitalistic Working Man

Two items side by side in the columns of a daily newspaper attracted the editor's attention the other day. The first item told how the employe of a large plumbing supply company are to assume control of the business following the death of the original owner; 50 of them are to become officers and directors at once, and it is planned that about 1000 employes will ultimately share the control. The second item announces the payment to employes of $700,000 in profit-sharing dividends by a great soap-manufacturing company.

Truly, the world do move! Twenty-five years ago, one of the first lessons a factory apprentice learned was that his superiors were not in the least interested in any ideas that he or his fellow workmen might have regarding the conduct of the whole business or any part of it. It is true that in all probability most of those ideas were worthless. Yet the very fact that any workman was at all interested in the business, beyond the confines of his own little job was usually looked on as a sinister Socialistic trend. (The horrible term Bolshevik or Communist was not heard in those days.) Nowadays, we find employes acting in the dual capacity of stockholder and employe of the company. True, they do not often control it outright, as in the first case mentioned, but the number of such instances is steadily on the increase. Can it be possible that the millenium has arrived?

How about the coal industry? Not many days ago, a certain high official of a large coal corporation was being questioned by the Senate Committee investigating the present conditions in the Pennsylvania coal fields. This official, according to the newspapers, stated in effect that, as far as he was concerned, he would prefer to consider that the miners were just as much subject to the control of the company as its physical property, to be dealt with as the company pleased.

For some time, the country as a whole has been wondering just what is the matter with the coal industry. A common explanation of its troubles is that there are too many mines and too many miners. The fact that sufficient coal for the country's needs was produced, even though many mines were closed last year for a considerable period, would seem to lend weight to this explanation. We are wondering, however, if there is not another factor involved. Is it possible that the attitude manifested by the above coal mine official toward his employes, as contrasted with the instances of employe stock ownership and co-operation typified by the two cases first mentioned, could possibly have any bearing on the unsettled condition of the coal workers? Is this unsettled condition fostered by certain miners' organizations, as is often alleged, or are its roots more deep-seated in the failure of the industry to recognize one of the significant trends of modern times—the increasing power of the workman who is at the same time a capitalist?

Satisfaction Vs. Progress

"When will you be satisfied?" asked an employer of his chief engineer after the latter had urged the installation of certain improvements.

"When I have become thoroughly satisfied," the chief replied, "I shall no longer be of much use to you or anybody else."

There is a marked distinction between constant desire to change things or stir them up merely for change's sake and constructive although critical tendency to examine the service rendered by each piece of apparatus and, in fact, each method of operation. Perfect contentment and progress cannot roost in the same nest. Equipment or method may be adequate for the time being but should not warrant complacency for an indefinite time on the part of operator or owner.

Improvement of method or reduction of cost of operation often justifies the scrapping or selling at a sacrifice of machinery or devices that are by no means worn out. It is reported that Andrew Carnegie once attributed a large part of his success to his early recognition of the economic value of the scrap-heap; that he frequently consigned to that place of oblivion machinery that was practically new or even had never been used, if he could replace it with something better by means of which his products could be improved enough, or lessen the manufacturing cost of these products sufficiently to warrant the expense involved in the change.

In making a change, the owner of a plant is most vitally interested in the ultimate appearance of the cost sheet. He is justified in expecting a change in equipment or method to result in transferring accounts from the wrong side of the ledger to the right side, therefore he must realize that changes, if they are not properly made, may lower the efficiency of his force.

The president of a large manufacturing plant in conservative, placid Baltimore once said that when he finds everything going smoothly and quietly in any part of his factory he knows that work is not being accomplished, so he proceeds to shake things up. Of course, he is wrong in supposing that noise spells progress; it is not the swashing of the water in the wake of a steamer nor the blasts from its whistle that do the propelling. Another important fact that was not comprehended by this president is the reaction of the worker to change as such and particularly after the worker has developed methods of operation or co-operation with others which change may destroy.

Adoption of new methods and new implements, when they improve product or decrease its cost, is very important but in their adoption we cannot discountenance the proper method of their introduction and the instinctive characteristics of those who are to use or operate them.

Acquirement of the hearty co-operation of the operator, based upon a thorough knowledge of how he re-

sponds under such conditions, is a very important factor in the success of a change. It is an element that too often is neglected when improvement is sought.

The Relation of Power Plants to American Business

Development of the commercial and domestic uses of electricity in America is a source of wonder to the rest of the world and is no doubt the cause of our remarkable industrial expansion. The use of power, the production of material and the scale of wages are directly related.

Ripley, in a small booklet published by the N. E. L. A., visualizes the mechanics of American business as six intermeshing gears driven by a single prime mover. This prime mover is an Efficient Power Plant which drives the six gears known as Cheaper Electricity, Wider Use of Electricity, Larger Output of all Commodities, Higher Pay and Lower Prices, Larger Purchases, and General Prosperity which in turn meshes on the other side with Cheaper Electricity.

Because of efficient power plants we have cheaper electricity and use more of it. This in turn gives us higher industrial production, justifying higher wages and lower unit costs, enabling the worker to make larger purchases and thus create general property. As a conclusion to his study of the situation, he says, "Through efficient power plants—the engineer has raised the standard of dignity of American labor—labor is now a director of power, not a generator of power, and works with brain far more than with muscle because of this wonderful mechanism."

Off Duty

Don Marquis, in that very delightful book of his, "The Almost Perfect State," recounts an amusing situation between the Universe and the Philosopher. The two sit and look at each other, satirically, arguing their relative importance in the order of things. The Universe is somewhat disconcerted by the Philosopher's assertion that, but for him (the Philosopher) the Universe would not exist, since the great part of the Universe, he claims, exists only in his mind, and if he saw fit not to think of that part—well, "where would you be?" he asks the Universe. The Universe, as we have said, is disconcerted by this line of reasoning and has no good "comeback." The Universe is averse to much profound thought anyway—says he'd rather lie about and drowse and watch the wheels go round. In fact, he claims he made everything spherical in the beginning so that it would roll when he kicked it. Whereupon the Philosopher calls the Universe a Low-brow.

Now, the Philosopher, as Don Marquis pictures him is rather a cocky fellow with considerably more impertinence than is good mannered, and somehow our sympathies go to the Universe. For, regardless of how much truth there may be in the Philosopher's remarks, the Universe is a likable old fellow with much solid character about him that can be admired. We, ourselves, like to see his wheels go round.

Since we first started to take serious interest in him, he has grown tremendously. When old Galileo first poked his little two-inch spy glass up into the heavens, he brought within the range of his vision some half a million stars. Today, with the 100-inch mirror of the Hooker telescope on Mt. Wilson, we are capable of recording, photographically, *more than a thousand million stars.*

Yet we have barely started. In the current number of Harper's Magazine, George Ellery Hale, honorary director of the Mt. Wilson Observatory, discusses the possibility of constructing telescopes having 200 or even 300-inch mirrors, telescopes, in other words, with objectives 25 feet across! Such a mirror would collect nine times as much light as the present 100-inch Hooker telescope and would increase the total number of stars to three or four times that now within range. This glass, then, would reveal to us some *four thousand million stars!*

Aside from the astonishing range of such a glass it would open up countless opportunities for productive research. It would give us marvelous facilities for analyzing the spiral nebule, now only just begun; it would aid us in our investigation of the structure of matter, and would give us a far better understanding of our own galaxy of which we still have much to learn. The possibilities of such a telescope are alluring, indeed.

There are some, and sometimes philosophers number among these, who would hold that science (and astronomy is a science) is merely a collection of dead facts that minister only to man's lower wants. These people would deplore the fact that astronomy has decentralized the world, that instead of being the all important center about which the whole universe turned, it is shown to be merely an insignificant speck of matter in an immeasurable system of countless galaxies. But these people do not know science. For if astronomy has decentralized the world, it has also revealed, as by an angel's hand, the true scope of the heavens and the import of the stars.

A thousand million stars! Is the thought of that staggering number of suns in any way destructive of one's religious or poetic philosophy? Does it injure one's finer sensibilities to gaze into the depths of space, beyond the boundaries of our own galactic system into the realm of spiral "island universes" and know that the first of these lies a million light years from the earth? Does the knowledge that there are suns a million times the size of ours, in any way, cramp one's ideals or distort one's outlook on life? We don't think so. If anything, such facts immensely widen capability for thought and religious expression.

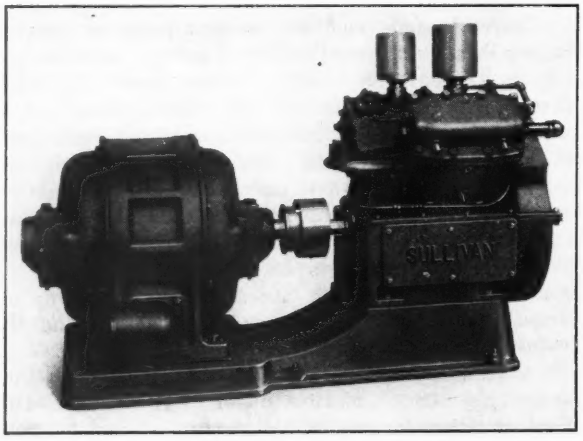
Science does not destroy mysteries nor does it ask men to live with empty hearts; instead it fills the world with meaning. Where before, the stars were just so many bright spangles set in a blue firmament, today they are the living players, as it were, unfolding before us a drama of transcendant grandeur.

So we repeat, our sympathies are with the Universe. The Philosopher may argue that the Universe is but a figment of his imagination, and he may be right, but we get a lot of satisfaction, as does the Universe, in watching the wheels go round.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

New Sullivan Vertical Air Compressor

FOR SHOP, power plant and miscellaneous industrial requirements in which a relatively small amount of compressed air is needed and where compactness, continuous operation and practically automatic control are important factors, the Sullivan Machinery Co., Chicago, Ill., has designed two new vertical direct motor-driven air compressors of the two-cylinder and four-cylinder types. These machines are intended for small plants or shops where air requirements are not large, or for use in large installations in which isolated departments need air, where the distance from the main compressor plant



NEW WL-44 MOTOR DRIVEN VERTICAL AIR COMPRESSOR, OF 240 C.F.M. DISPLACEMENT HAS V-TYPE CYLINDER ARRANGEMENT

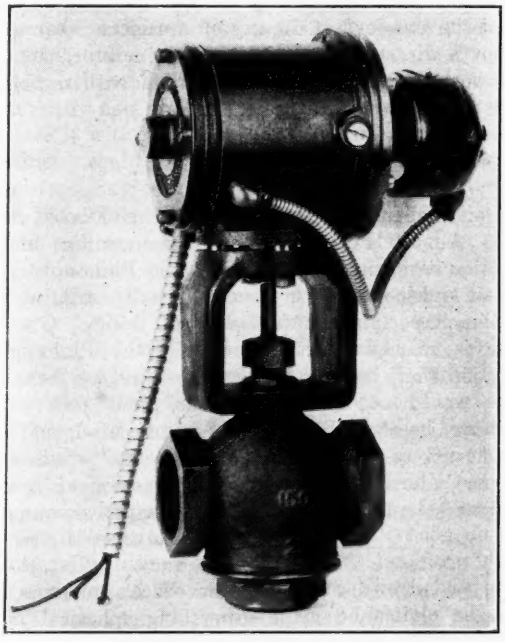
is considerable, or for standby or night service when it is desired to save operating costs by shutting down the main compressor unit. Both machines are single acting.

Instead of using two large cylinders, the four-cylinder vertical compressor employs four of a proportionately smaller size. The cylinders are placed in pairs at an angle of 90 deg. with each other, forming the V-type arrangement shown. As the two connecting rods for opposite cylinders attach side by side on one crank-pin, only two cranks are required for the four cylinders. The shaft is but slightly longer than that used in a conventional two-cylinder machine and requires the same number of bearings for its support. The light weight of the reciprocating parts and the V-type arrangement are intended to reduce to a minimum the forces causing vibration.

These two machines have a capacity of 120 and 240 cu. ft. of free air per minute respectively. Direct and alternating current motors, together with control equipment for hand starting and stopping or for full automatic control, are available. Automatic control of the compressor cooling water may also be arranged to stop the flow of the water when the motor is at rest and to start the circulation when the motor is again placed in motion.

New Bristol Motor-Operated Valve

DESIGNED FOR pressures ranging from 150 lb. per sq. in. to 75 lb., a new motor-operated valve, recently placed on the market by The Bristol Co. of Waterbury, Conn., lends itself to many applications.



BRISTOL TYPE "B-K" VALVE

It can be used for steam, water or compressed air and is unusually rugged in construction. It has a high ratio between motor and valve speeds, and provision has been made for keeping the high temperatures of steam lines away from the motor and operating mechanism.

Referring to the accompanying illustration, it will be noted that a heavy globe valve body of standard design is employed, and that the operating unit is supported well clear of it on a rigid bracket of such design

as to eliminate the possibility of "lost motion" between the gear train and the valve stem. The valve is operated by a cam, acting on a follower directly in the line of the stem and tending to force it to the open position. The speed reduction from the motor to the cam shaft is accomplished by a train of cut spur gears arranged about the circumference of a circle in a manner which reduces to a minimum the possibility of misalinement or improper meshing. All gearing is totally enclosed in a cast metal gear box.

The motor is of a standard make, is carried upon one end of the gear box by a waterproof mounting, and has a power consumption of about 25 watts. The time of opening or closing the valve approximates 12 sec. In a readily accessible compartment within the end of the gear box remote from the motor, is mounted a limit switch whose function is to clear the motor circuit when the operation of opening or closing the valve is completed. This switch is actuated by a small cam carried on the main cam shaft, and is thus positively interlocked with the valve. The switch parts are constructed of heavy phosphor bronze strip with tungsten contacts; and the whole is mounted as a unit within a moulded bakelite casing. All wiring between the switch and the motor is enclosed in flexible armored conduit; and provision is also made for attaching directly to the body of gear box the conduit which carries the conductors from the control switch.

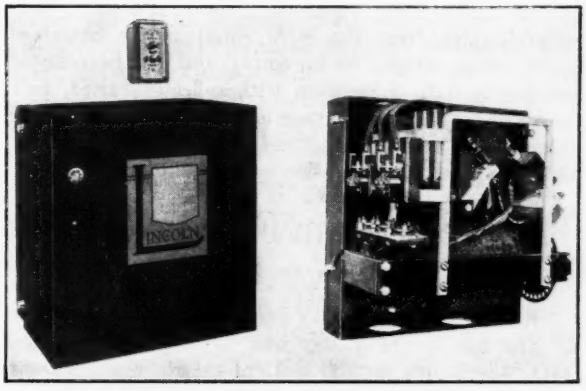
This valve is not of the "floating" type, but comes to rest either tightly closed or wide open. Thus the motor is not required to reverse, but when started continues to run until the cam has made half a revolution, closing or opening the valve as the case may be; when the circuit is automatically cleared by the action of the limit switch. While the valve is designed with a particular view of being operable by the Bristol temperature controller, it is capable of a great variety of wiring arrangements; and complete control may be obtained with a single pole double throw switch, one position corresponding to "open" and the other to "closed". Ordinarily the switch must be left in either position for a time interval at least sufficiently long for the valve to complete its motion and clear its own circuit; but if for any reason this is not practicable, it is a simple matter to interpose a relay which will maintain operation once a touch contact has been made by the control switch.

Type "B-K" valve lends itself particularly to installation on the steam lines to dry kilns, sizing tanks, dye vats, and in fact to any service where there is required the automatic or remote control of temperature or humidity by means of steam. It is also applicable to the control of water supply for heating or cooling purposes, or to the control of water level in storage tanks for processes, or for fire protection. It should, moreover, find a wide use around the power plant, in any place where the control of steam, air or water from a remote point is desired. It is available in all sizes from ½ in. to 2½ in., and for pressures from 150 lb. in the smaller sizes to 75 lb. in the larger. The motor can be supplied for any of the standard voltages or frequencies.

THE WORST kind of exercise is jumping at conclusions.

New Automatic Induction Starter

NEW AUTOMATIC induction starter, with two adjustable features has just been announced by the Lincoln Electric Co., Cleveland, Ohio. One of the adjustments is in the starting current and starting torque



AUTOMATIC INDUCTION STARTER WITH TWO ADJUSTABLE FEATURES

and is made by changing the position of the rotor in the regulator. This rotor is index mounted and the starting torque and starting current of the motor are increased by going to the higher numbers of the scale and decreased by going to the lower.

The other adjustment is in the current at which the throw-over takes place. The throw-over in this new starter is controlled by retarding solenoid which is operated by the motor current. The pull of this solenoid can be adjusted by a simple lock rod arrangement carried on its plunger.

This switch is designed so that, if the front cover is removed, the switch may be swung forward by the removal of the holding screw at the back. This brings the switch mechanism out where it is in a better position for observation. The barriers may also be moved upward out of the way. By the release of a screw on the control switch panel the contact carrying arm will drop back exposing all contacts for renewals or observation. The barriers completely enclose the contacts and six separate arc chimneys are provided to confine the arcs.

The contacts in this switch are designed to give that wiping action which is a feature of the modern switch. Overload protection is afforded by thermo-relays and the no-voltage protection by no-voltage release control.

A Portable Lighting Unit

A PORTABLE ACETYLENE FLARE LIGHT has been added to the line of the Oxweld Acetylene Co., 30 East 42nd Street, New York City. The fuel used is acetylene, produced from Carbic. This material is in the form of cakes of uniform size and cylindrical shape. If the use of the light is discontinued before the entire charge is used, the portion remaining can be left in the holder, or, being dry, solid and clean, can be slipped back into the drum for later use.

This flare light is designed to operate under all

climatic and weather conditions; it is equipped with a storm-proof burner.

Carbic flare lights are manufactured by the American Carbolite Co., Inc., and Oxweld Acetylene Co., New York City is the sole distributing agent. Carbic, the fuel used, is marketed exclusively through Union Carbide Sales Co., New York City. Both products are handled by jobbers in principal cities.

The Carbic light is available in several styles. They range in size from the 8000 candle-power Standard model, which weighs 36 lb. empty and 115 lb. charged and stands 6 ft. 7 in. high with reflector raised, to a hand light. A double burner model, which will furnish illumination in two directions simultaneously, is furnished in about the same size as the Standard model.

St. Francis Dam Failure Causes Heavy Loss

FOLLOWING CLOSELY the recent flood disasters in the Mississippi Valley and in the New England States, the failure on March 12 of the St. Francis Dam, an important part of the Los Angeles, Calif., water supply system, has startled the country but its suddenness and by the accompanying destruction of life and property.

FIG. 1. CENTRAL SECTION OF ST. FRANCIS DAM REMAINS STANDING

As shown in Fig. 1, the dam failed at both sides, from some cause that has not yet been determined, leaving the center part of the structure still standing. This part is about 100 ft. wide. Concrete from the right wing of the dam (shown at the left in the photograph, which was taken looking upstream) was washed downstream in pieces the size of a bungalow, according to reports. Concrete from the other wing did not wash downstream, but toppled over as shown in Fig. 2.

St. Francis Dam is located in San Francisquito Canyon, about 40 mi. north of Los Angeles. Below the dam was a hydroelectric plant of about 50,000 kw. capacity supplying the Los Angeles municipal power system. It is reported that this plant was destroyed by the 15-ft. wall of water that swept down the Santa Clara Valley after the dam broke and that all the operators and their families, totaling 64 persons, lost their lives. Another municipal hydro plant of 40,500-kw. capacity, located above the dam, is reported unharmed. A camp belonging to the Southern California Edison Co., located in the path of the flood, was wiped out with an estimated loss of 40 of the company's workmen.

When the municipal power system was shut down following the catastrophe, the load was immediately taken over by the Southern California Edison Co.

Philadelphia to Have Materials Handling Meeting

ANNOUNCEMENT IS MADE by the American Society of Mechanical Engineers of the National Materials Handling Meeting to be held at the Benjamin Franklin Hotel, Philadelphia, Pa., on April 23 and 24.

On Monday morning, April 23, after registration, a technical session at 10:15 a. m. will hear papers on Material Handling Methods at the Eastern Steel Castings Co., by Frank D. Campbell, Chief Engineer, and on Materials Handling of the deLavand process of Casting Pipe Centrifugally, by H. A. Hoffer, Eastern Manager, U. S. Cast Iron Pipe & Fdry. Co.

In the afternoon, various inspection tours will be held and in the evening at 7 o'clock an informal dinner will take place.

On Tuesday, the morning technical session at 9:30 a. m. includes papers on Handling Methods in Railroad Transportation, Steamship Piers and Delivery of Freight by Motor Trucks. At 2 p. m. a technical session on Interior Handling will be held simultaneously with a session on Bulk Handling. The latter session includes a paper on methods and equipment for fuel handling and ash removal by James R. McCausland, Supt., Coal Bureau & Steam Heat Section, Philadelphia Electric Co., and other papers on handling of coal, ash and ore and other bulk materials.

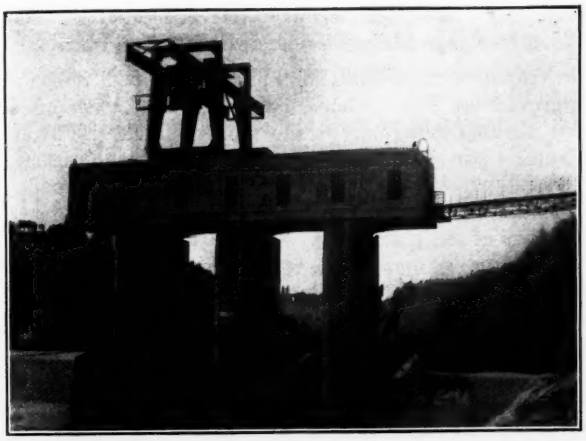
FIG. 2. LOOKING DOWNSTREAM FROM BEHIND DAM, DEBRIS OF LEFT WING OF DAM IS SEEN

On Tuesday evening, after a supper at the hotel at 6:15, another technical session will be held at 8 p. m. Complete details can be obtained from the Secretary of the American Society of Mechanical Engineers, 29 W. 39th St., New York City, and reservations for rooms should be made directly to the Benjamin Franklin Hotel at Chestnut and 9th Sts., Philadelphia, Pa.

Lock No. 7 Hydro Plant Nears Completion

IN THE ACCOMPANYING illustration is shown the new Lock 7 hydro-electric plant of the Kentucky Hydro-Electric Co., rapidly nearing completion on the Kentucky River about 3 mi. below Dix Dam. It is expected that the plant, which is of 2500 hp. capacity, will be in operation some time in April.

Because of the extreme height of the flood waters of this river, also because of a government ruling that the full spillway area of the dam must be preserved, the plant was built on three concrete piers, as shown, thus allowing free passage of flood waters, which rise to a point only a few feet below the floor line. The water wheels are located in the base, their vertical shafts extending up through the piers to drive the generators



LOCK 7 HYDRO PLANT ON KENTUCKY RIVER UNDER CONSTRUCTION

located in the superstructure at the top. The Lock 7 plant will be of the automatic type. It was designed by L. F. Harza, consulting engineer of Chicago.

High-Pressure Boilers for Deepwater Plant

STEVENS AND WOOD, INC., acting as agents for The American Gas & Electric Co., and the United Gas Improvement Co., have placed an order with The Babcock & Wilcox Co. for six high-pressure boilers for the new Deepwater Plant.

Four of these units are standard boilers, 53 sections wide, each section being 8 tubes high; tubes are 3¼ in. in diameter, 20 ft. long, the sections being connected to a forged steel drum 4 in. thick, 52 in. internal diameter. The heating surface of each unit is 9623 sq. ft. The boilers are to be equipped with Babcock & Wilcox convection superheaters designed to give an ultimate steam temperature of 725 deg. when the boiler is generating at a rate of 331,000 lb. of steam an hour. Boilers will also be equipped with Babcock & Wilcox wrought steel, return-bend economizers of the steaming type. Each economizer will contain 18,326 sq. ft. of heating surface.

Two of the units are reheat boilers, the boiler sections having the same size and arrangement of heating surface and are identical with the standard boilers. The superheaters are of the convection type designed to give an ultimate steam temperature of 725 deg. when the boilers are delivering 290,000 lb. of steam per hour. The reheater elements are of the Babcock & Wilcox wrought steel return bend construction, designed to reheat a maximum of 419,000 lb. of steam an hour at an initial pressure of 385 lb. and a temperature of 487 deg. to an ultimate temperature of 775 deg. The reheat boilers are to be equipped with Babcock & Wilcox wrought steel return bend economizers containing 4763 sq. ft. of heating surface each.

Both standard and reheat boilers are built for a working pressure of 1350 lb. per sq. in.

News Notes

NATIONAL MEETING on Oil and Gas Power is being planned for June 14 to 16 to be held at Pennsylvania State College, State College, Pa. In connection with the meeting will be an exhibition of oil and gas engines, parts and accessories, held in the new mechanical laboratory of the college. The technical program calls for a number of sessions on subjects such as Power Economics, Fuel Oil Specifications, Research and Specialization in Manufacturing. The meeting is held jointly by the Oil and Gas Power Division of the A. S. M. E. and the Pennsylvania State College. Professor F. G. Heckler is chairman of the committee of arrangements at State College and E. J. Kates, chairman of the Oil and Gas Power Division at 29 W. 39th St., New York, is in charge of Pullman reservations from New York and Philadelphia.

FURTHER DETAILS of the program of the District Heating School to be held at Purdue University, Lafayette, Ind., from May 21 to 26, inclusive, under the auspices of the National District Heating Association, have just been given out by D. L. Gaskill, secretary of the association. Preliminary announcement of this school was made in our February 15 issue. Two separate and simultaneous courses will be given at the school. Course 1 deals with the more fundamental subjects, which should preferably be taken this year by all who did not attend last year's course. It includes instruction in heat and the properties of steam, heat losses from buildings, heating and ventilating systems, design of heating systems, flow of steam in pipes and trends in steam power plant design and operation. Course 2 covers more advanced and applied subjects. These are: underground construction, distribution system design, operation of building heating systems, reducing valves, traps and appliances, meters and rates, estimating heat consumption of buildings, trends in steam power plant design and operation. Those who attended last year's course should enroll for this work and it will be repeated in 1929 for those who take Course 1 this year. The choice of courses is, however, largely optional with the student. Applicants should have a grade school or high school training but need not be college graduates. Anyone interested in the subject of district heating is invited to enroll; membership in the N. D. H. A. is not required. A charge of $10 for the week's tuition will be made by the University. Full information regarding registration, living accommodations and necessary equipment can be

obtained from Professor C. H. B. Hotchkiss, Purdue University, LaFayette, Ind. Anyone intending to enroll for the school should secure an enrollment blank from Professor Hotchkiss and file it with him before May 1.

REGULAR SPRING Group Meeting of the committees of the American Society for Testing Materials was held at the Mayflower in Washington, D. C., March 21, 22 and 23. In all, 26 committees of the society took part, involving 475 members. In addition, meetings were held at the Joint Research Committee of the A. S. T. M. and the A. S. M. E. and of other joint committees of the society on properties of metals, cast-iron pipes and other subjects of present interest. An informal dinner was held on Thursday evening, when the members had the pleasure of hearing the Hon. Wm. McCracken, Jr., assistant secretary of commerce for aviation, and Admiral H. H. Rousseau, in charge of naval oil reserves.

LEWIS INSTITUTE branches of the A. I. E. E. and W. S. E., Lewis Institute, 1951 W. Madison St., Chicago, Ill., announce their second annual engineering exposition to be held May 16, 17 and 18.

BOARD OF TRUSTEES of the Stevens Institute of Technology, Hoboken, N. J., gave a dinner at the Hotel Astor, New York, on March 15 in honor of Dr. Harvey Nathaniel Davis of Harvard University, who has been elected president of the Institute to succeed the late Dr. Alexander C. Humphreys. Dr. Davis will assume his new duties September 1.

EXECUTIVE OFFICES of the Worthington Pump & Machinery Corp. also its export sales department and New York district sales department were moved to No. 2 Park Avenue, New York City, on April 1. The head office, sales and advertising departments of the company have been moved to the Harrison plant of the corporation at 421 Worthington Avenue, Harrison, N. J.

FOLLOWING THE ESTABLISHMENT of a complete manufacturing plant at Belleville, Ontario, the Stephens-Adamson Mfg. Co. of Canada, Limited, has opened branch sales engineering offices at Bank of Hamilton Building, Toronto, Ontario, with A. F. White in charge, and at the new Birks Building, Montreal, Quebec, in charge of George H. Smith.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., has appointed R. T. Stafford, formerly of the Seattle office, as assistant manager of the Electrical Department in charge of sales and engineering at Pittsburgh Transformer Works. John Alberts of the Seattle office has been appointed district manager, succeeding Mr. Stafford.

DEARBORN CHEMICAL CO., 310 S. Michigan Ave., Chicago, Ill., announces that E. M. Converse has recently been appointed sales manager of the company. He relieves W. A. Converse, secretary and chemical director, who has served as director of sales in the stationary department for many years and who will now devote his attention to matters of general company operation.

GENERAL ELECTRIC CO., Schenectady, N. Y., announces that the Yellow Cab Co. of Philadelphia has built and tested several taxicabs with gas electric drive. In this unit, a direct-current generator is driven by the gasoline engine and a direct-current motor is connected to the drive shaft, with suitable reversing mechanism. Speed is controlled by throttling the engine and the design is intended to provide speed and flexibility and to permit the gasoline engine to run at its maximum power point without necessity for gear changing.

WM. B. SCAIFE & SONS CO., Oakmont, Pa., announces that William K. Capers, formerly tank salesman for the company, has been appointed manager of the company's Chicago office, First National Bank Bldg., Chicago, Ill., to succeed Charles Faber O'Hagan.

L. S. SHAW & SON is the new name under which the former L. S. Shaw & Co. has reorganized, C. D. Shaw having entered the firm under date of February 15. The company has headquarters at Meriam Bldg., 5716 Euclid Ave., Cleveland, Ohio.

CASEY-HEDGES CO., Chattanooga, Tenn., announces that William Wallace, Jr., Cleveland, Ohio, who formerly represented the Erie City Iron Works, now represents the Casey-Hedges Co. in the Cleveland, Youngstown and Pittsburgh territory. He is located at 1111 Union Mortgage Bldg., Cleveland, Ohio.

VOTERS OF MARSHALL, MO., population 7500, recently approved an $80,000 bond issue for installation of a new turbine generator at the municipal electric light plant. Upon completion of this improvement, nearly $266,000 will be invested in the plant out of city funds, with another $200,000 equipment expenditure from earnings of the plant.

THE BOARD OF WATER COMMISSIONERS, City Hall, Detroit, Mich., has plans for a complete waterworks plant in the Springwells section, including a high-pressure pumping station with a capacity of 200,000,000 gal. a day.

WESTERN UNITED GAS & ELECTRIC CO., Aurora, Ill., has been authorized to take over property, business and assets of the Western Public Service Co., which it organized 3 yr. ago to furnish electric service to a dozen communities along the Burlington road in the Aurora district.

INTERSTATE POWER CO., 1000 Main St., Dubuque, Iowa, is considering the construction of a power plant for local service at Harper's Ferry, Iowa.

CLEVELAND ELECTRICAL TRAMRAIL Division of the Cleveland Crane & Engineering Co., Wickliffe, Ohio, has appointed Leeds, Tozzer & Co., Inc., 75 West St., New York, as its representatives.

ILLINOIS POWER & LIGHT CORP. has been authorized, upon rehearing of its petitions, to purchase the Arenzville Light and Power Co. property for $74,000 and the Prather and Hill Electric Light Co. and the Elkhart Light Co. for $40,000, and has been granted certificates of convenience to serve the territories.

WASHINGTON WATER POWER CO., Spokane, Wash., has tentative plans under way for a 150,000-hp. hydroelectric development on the Columbia River near Kettle Falls. Miles Birkett is vice president.

NECESSITY FOR speeding up the 1928 construction program of the various public utilities companies in which the United Gas Improvement Co. is interested, has been urged upon officials of the company by Arthur W. Thompson, president, as a means of affording some relief for the unemployment situation in Philadelphia and

vicinity. The budgets of the companies in which the U. G. I. has an interest provide for the expenditure of approximately $20,000,000 for construction work of all kinds in the Philadelphia metropolitan area, Eastern Pennsylvania, Northern Delaware and other eastern states. In a letter sent to W. W. Bodine, vice president in charge of finances and chairman of the company's management committee, Mr. Thompson calls attention to the discussions of unemployment in this country and urges the committee to consider what projects covered by the budget could be started at an early date. The management committee supervises all the construction budgets of the U. G. I. company.

ORDER for a large high-pressure steam generating unit has been placed with Walsh & Weidner Boiler Co. of Chattanooga, Tenn., by the Detroit Edison Co. This unit is a five-drum, bent-tube boiler of 3000 hp. capacity, designed to operate at 420 lb. per sq. in. working pressure.

CARROLL G. BENNETT, chief engineer of the Illinois Commerce Commission, who has resigned to become chief engineer for the Public Service Co. of Northern Illinois, was presented with a gold watch by employes of the commission recently as a farewell token.

IOWA RAILWAY & LIGHT CO., Cedar Rapids, Iowa, has approved plans for the construction of a steam power plant at Webster City, Iowa.

NORTHERN CONNECTICUT LIGHT & POWER CO., Thompsonville, Conn., has engaged the J. G. White Engineering Corp., 43 Exchange Place, New York, to prepare plans for its proposed hydroelectric plant on the Connecticut River near Windsor Locks, for which a permit was recently secured.

CHARLES H. TENNEY & CO., 200 Devonshire St., Boston, Mass., has plans under way for a new steam generating plant on the waterfront at Salem, Mass., reported to cost in excess of $1,000,000. State and federal permission has been requested and it is proposed to proceed with the project at an early date.

Books and Catalogs

A PRIMER OF BLUE PRINT READING is the title of an interesting little book by Thos. A. Diamond, published by The Bruce Publishing Co., Milwaukee, Wis. It is a text on blue print reading prepared to give students in industrial arts work a working knowledge of how to read blue prints. It is divided into two parts, Part I providing a series of mechanical drawings which the learner is asked to interpret by answering questions concerning dimensions, construction relation, etc., of the objects shown. Part II applies the principles learned in Part I in a series of dimensioned perspective sketches and incomplete projection drawings which the student completes by supplying missing views and dimensions. The price of the booklet is 48 cents.

NATIONAL ELECTRIC MANUFACTURERS ASSOCIATION has issued the NEMA Handbook for Power Switchboard and Switching Equipment, a revised publication including Instructions for the Installation, Operation and Care of Power Switchboards, Oil Circuit Breakers, Power Switching Equipment; Standard Definitions; Power Switchboards and Switching Equipment Standards; and A. E. S. Safety Standard for Switchboards, Oil Circuit Breakers and Oil Switches. The publication is illustrated. The price of the book is $1.00.

IN A RECENT 32-page attractively illustrated booklet, Dry Quenching Equipment Corp., a subsidiary of International Combustion Engineering Corp., 200 Madison Ave., New York City, gives the first comprehensive presentation of the Sulzer system for dry quenching of coke. Description of the process is given, together with illustrations of installations in this country and abroad, and much interesting engineering data on the principles and details of the process. Copies of the booklet, No. DQ-2, will be sent on request to those interested.

THE JOHNS HOPKINS UNIVERSITY, Baltimore, Md., has just issued a reprint of a lecture by W. R. Addicks, senior vice-president, Consolidated Gas Co., of New York, on "The Gas Supply of the Modern City—Today and Tomorrow."

LA MONT CORP., 200 Fifth Ave., New York City, is issuing a four-page folder showing applications of the LaMontube screen in steam generation.

SOLVING the Boiler Scale Problem with Sand-Banum, is the title of a booklet just issued by American Sand-Banum Co., Inc., 344 Madison Ave., New York City.

STONE & TAR PRODUCTS CO., 97 S. 6th St., Brooklyn, N. Y., in a recent booklet, describes patent materials for structural repairs and plant maintenance.

SILENT HOIST WINCH & CRANE CO., INC., 762 Henry St., Brooklyn, N. Y., in bulletin No. 27, just issued, describes Silent Hoist vertical and horizontal capstans, single and double drum winches.

COCHRANE CORP., Philadelphia, Pa., in a new bulletin, No. 676, describes auxiliary equipment for use in heating systems and industrial plants. The bulletin describes and illustrates various types of heaters, steam and oil separators, traps, valves, filters and fluid meters, and discusses the methods of using them.

HUGH L. COOPER & CO., INC., 101 Park Ave., New York City, has issued a folder discussing its work and giving data on the Keokuk and Wilson Dam projects, which it designed.

TUNGSTONE house-lighting batteries are illustrated and described in a 28-page booklet issued by Tungstone Accumulator Co., Ltd., 3, St. Bride's House, Salisbury Square, London, E. C. 4.

LEEDS & NORTHRUP CO., Philadelphia, Pa., in bulletin No. 870, a 36-page illustrated book, describes potentiometers for temperature control in oil refining.

LINCOLN LINC-WELD MOTORS are described in detail in a 26-page illustrated bulletin just issued by the Lincoln Electric Co., Cleveland, Ohio.

FAULKNER'S IMPROVED BOND, a high pressure cement for furnaces, is described in a folder recently issued by the J. A. Faulkner Refractories Co., 523 W. Federal St., Youngstown, Ohio.

H. W. CALDWELL & SON CO., Western Ave., 17th and 18th Sts., Chicago, Ill., subsidiary of Link-Belt Co., has just issued Book No. 989, describing the original Caldwell Helicoid and sectional flight screw conveyor. This gives complete details of the conveyor with tables of dimensions and price list.

Power Plant Construction News

Ariz., Tucson—The Pacific Fruit Express Co., 65 Market Street, San Francisco, Calif., will install power equipment in a proposed refrigerator car repair plant on local site. Entire project will cost more than $200,000.

Ark., Booneville—The City Council plans the installation of pumping machinery and auxiliary equipment in connection with a proposed municipal waterworks. Entire project will cost in excess of $200,000. McDonald, McCullough & Proctor, Inc., Booneville, is engineer.

Calif., Hynes—The Clearwater-Hynes County Water District is having plans drawn for a local waterworks, to include electric-operated pumping machinery, one 100,000-gal. elevated steel tank and tower, with accessory equipment. The Burns-McDonnell-Smith Engineering Co., Western Pacific Building, Los Angeles, is engineer.

Colo., Lamar—The Southern Colorado Power Co., Pueblo, is concluding negotiations for the purchase of the local municipal light and power plant and plans to remodel and improve with installation of additional equipment for enlarged capacity; a transmission line will be constructed.

Ga., Buena Vista—The Atlantic Ice & Coal Co., Atlanta, Ga., is considering the installation of a cold storage and refrigerating plant, reported to cost about $65,000 with equipment.

Ill., Bluford—The Central Illinois Public Service Co., Springfield, Ill., has approved plans for the construction of a one-story ice-manufacturing plant on local site, reported to cost about $100,000. Murray Hanes, 205 South Sixth Street, Springfield, is architect.

Ill., De Kalb—The Illinois Northern Utilities Co., De Kalb, is said to be planning the construction of a new artificial gas plant, reported to cost about $450,000 with equipment. L. D. Adams, company office at Dixon, Ill., is engineer.

Ill., East St. Louis—The Midwest Rubber Reclaiming Co., operated by the Akron Rubber Reclaiming Co., Barberton, Ohio (address last noted), plans the construction of a one-story steam power plant at its proposed new local mill. Entire project will cost about $175,000. S. G. Luther is manager of parent company, in charge.

Ill., Pekin—The Fleischmann Yeast Co., 327 South La Salle Street, Chicago, Ill., plans the installation of power equipment in a new three-story local plant, entire project to cost about $400,000.

Ind., Connersville—The Auburn Automobile Co. plans the installation of power equipment in a proposed new one-story addition to cost approximately $100,000 with machinery.

Iowa, Waterloo—The Rath Packing Co. has plans maturing for a one-story addition to power plant, reported to cost more than $30,000, with equipment. Henschien & McLaren, 1637 Prairie Avenue, Chicago, Ill., are engineers.

Mass., Weymouth—The Edison Electric Illuminating Co., 39 Boylston Street, Boston, has approved plans for the construction of a steam power house and switching plant on local site, to cost more than $2,000,000. Work will be in charge of Stone, Webster, Inc., 49 Federal Street, Boston.

Mich., Princeton—The Cliffs Power & Light Co., operated by the Cleveland-Cliffs Iron Co., Ishpeming, Mich., will soon begin construction of hydroelectric power plant on the Escanaba River, near Princeton. Entire project reported to cost more than $650,000 with transmission system.

Minn., Willmar—The City Council has authorized plans for extensions and improvements in municipal electric power plant, with installation of additional equipment. The Pillsbury Engineering Co., 2344 Nicollet Avenue, Minneapolis, Minn., is engineer.

Mo., St. Joseph—The Stewart Inso Board Co., Lake Road, plans the installation of power equipment in a new addition, comprising three units, estimated to cost $200,000. A. D. Stewart is president.

Mo., St. Louis—The Great Atlantic & Pacific Tea Co., Graybar Building, New York, will install power equipment in a new four-story baking and distributing plant to be erected at 4525 Scott Avenue, reported to cost $750,000 with machinery.

Mo., St. Louis—The Waxide Paper Co., 404 Admiral Street, Kansas City, Mo., plans the installation of power equipment in a proposed new waxed paper-manufacturing plant on Newstead Street, St. Louis. Entire project will cost more than $200,000.

N. C., Shelby—The Cleveland Cloth Mills Co. will install power equipment in a proposed new two-story addition to its textile mill estimated to cost close to $200,000.

Neb., Omaha—Haskins Brothers & Co., 115 Hickory Street, plan the installation of power equipment in a proposed three-story soap-manufacturing plant, to cost about $85,000.

N. J., Paterson—The Pure Ice Co., 21 North First Street, has plans for a one-story ice-manufacturing plant to cost about $35,000 with equipment.

N. Y., Binghamton—The Fairbanks Co. plans the installation of power equipment in connection with proposed rebuilding of portion of its local plant recently destroyed by fire with total loss estimated in excess of $150,000. Headquarters are at Broome and Lafayette Streets, New York.

N. Y., Buffalo—The Buffalo Flour Mills Corporation, Chamber of Commerce Building, will install power equipment in connection with proposed rebuilding of its mill on Ohio Street, partially destroyed by fire March 27, with loss reported at $240,000.

Ohio, Cleveland—The Great Lakes Portland Cement Co., Marine Bank Building, Buffalo, N. Y., A. L. Beck, president, plans the construction of a steam power plant at its proposed local mill on the Cuyahoga River, vicinity of Cleveland, for which plans are maturing. Entire project will cost about $1,000,000.

Ohio, Cleveland—The Otis Steel Co., 3341 Jennings Road, plans the installation of power equipment in a proposed new mill addition to Clark Avenue, to cost $450,000. E. J. Kules is president.

Ohio, Wooster—The Safety Stair Tread Co., Wooster, plans the installation of power equipment in a new one-story and basement plant addition, to cost about $125,000 with machinery. Christian, Schwarzenberg & Gaede, 1900 Euclid Avenue, Cleveland, Ohio, are engineers.

Okla., Enid—The Pillsbury Flour Mills Co., Minneapolis, Minn., plans the installation of power equipment in its proposed local flour mill and elevator, estimated to cost close to $1,000,000 with machinery.

Pa., Meadville—The Viscose Co., Marcus Hook, Pa., plans the construction of a boiler plant at its proposed local rayon mill. The entire project will cost more than $500,000.

Pa., Pittsburgh—The Mine Safety Appliance Co., Braddock and Thomas Avenues, plans the installation of power equipment in a new three-story factory addition to cost about $200,000. Barnard H. Prack, Martin Building, is architect.

R. I., Providence—The United States Finishing Co. plans the installation of power equipment in a two-story addition to its textile mill. Entire project will cost close to $90,000.

Texas, San Antonio—The San Antonio Tanning Co., 110 East Hursache Street, plans installation of power equipment in a proposed new leather tannery at Fratt, near San Antonio. Entire project will cost $100,000. S. L. Gill is president.

Va., Staunton—A. Schottland, Inc., 39 Madison Street, Paterson, N. J., is considering the construction of a boiler house at a proposed local silk mill. The entire project will cost more than $150,000.

Wis., Appleton—The Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., will install power equipment in a proposed addition to its local paper mill, to cost about $350,000. Childs & Smith, 720 North Michigan Avenue, Chicago, Ill., are architects.

Wis., Oshkosh—The Board of Regents, State Normal School, Capitol Building, Madison, Wis., has preliminary plans for a new steam plant at this institution in Oshkosh, estimated to cost $85,000. Arthur Peabody, Capitol Building, Madison, is state architect.

Wis., Racine—The Modine Mfg. Co., Seventeenth and Racine Streets, plans the installation of power equipment in a proposed addition to its automobile radiator manufacturing plant. Entire project will cost about $100,000. Architect will soon be selected.